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OFFICE OF CHEMICAL SAFETY AND POLLUTION PREVENTION

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MEMORANDUM

Subject: Registration Review – Ecological Risk Assessment for Coumaphos

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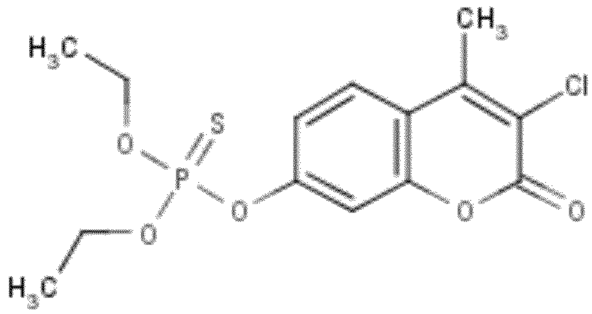
Attached is the ecological risk assessment for the Registration Review of the insecticide/ acaricide coumaphos.

REGISTRATION REVIEW

ECOLOGICAL RISK ASSESSMENT AND EFFECTS DETERMINATION

Coumaphos



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Contents

1 Executive Summary

The purpose of this screening-level ecological risk assessment is to evaluate potential risks to non-target species, both non-listed and federally-listed endangered and threatened species (hereafter referred to as non-listed and listed species, respectively) from registered uses of coumaphos as part of the Registration Review program[1] pursuant to Section 3(g) of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

Coumaphos (3-chloro-7-diethoxyphosphinothioyloxy-4-methylcoumarin) is an organophosphate insecticide/acaricide used to control flies (face fly, horn fly), ticks, lice, mites (scabies mite) and screw worms on livestock (*e.g.*, dairy cattle, horses, sheep, and swine) and swine bedding, and to control varroa mites and small hive beetles in bee hives.

This assessment considers potential exposure to coumaphos as a result of the application of coumaphos to livestock and in-hive use of coumaphos. The latter exposure pathway of concern is considered only for honey bees. **Table 1-1** provides a list of the exposure pathways by taxon that are considered in this assessment for the application of coumaphos to livestock.

Table 2-1. Exposure Pathways by Taxon for Application of Coumaphos to Livestock

Taxon	Exposure Pathways Assessed
Birds	☐ contact with/ingestion of hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas ☐ ingestion of contaminated bird carcasses ☐ ingestion of food items on land receiving manure from Concentrated Animal Feeding Operations (CAFOs) ☐ ingestion of contaminated fish
Mammals	☐ ingestion of contaminated bird carcasses ☐ ingestion of food items on land receiving manure from CAFOs ☐ ingestion of contaminated fish
Terrestrial plants*	☐ uptake from CAFO manure applied to land ☐ uptake from soil receiving runoff from land to which manure from CAFOs has been applied
Fish, aquatic invertebrates, and aquatic plants	☐ uptake from surface waters receiving runoff from land to which contaminated manure has been applied ☐ uptake from surface waters receiving runoff from non-regulated small CAFOs (*i.e.*, < 300 animals) ☐ uptake from surface waters receiving runoff from rangeland where treated livestock graze ☐ uptake from surface waters into which treated livestock wade (*i.e.*, wash-off from treated livestock that enter bodies of water)

* Given the low application rates calculated for runoff from rangeland where treated livestock graze (see **Table 4-6**), uptake from soil receiving runoff from rangeland where treated livestock graze was not considered to be an exposure pathway of consequence.

A summary of direct effects to listed and non-listed taxa from registered uses of coumaphos is provided in **Tables 1-2** and **1-3**.

[1] http://www.epa.gov/oppsrrd1/registration_review/

Table 1-2. Summary of Direct Effects for Aquatic Organisms

Taxon	Status	Concern for risk from direct effects?*	Basis for Conclusion					
			RQ exceedance (type: acute and/or chronic)?				Incidents?	Comments
			Exposure pathways:					
			Runoff from land to which CAFO manure has been applied	Runoff from non-regulated small CAFOs (*i.e.*, < 300 animals)	Runoff from rangeland	Wash-off from treated livestock that enter bodies of water		
Freshwater fish and aquatic-phase amphibians	Listed	No	No	No	No	No	No	--
	Non-Listed	No	No	No	No	No		
Estuarine/marine fish	Listed	No	No	No	No	No	No	--
	Non-Listed	No	No	No	No	No		
Freshwater invertebrates	Listed	Yes	Texas, Rest of U.S.: Yes (acute & chronic)	Texas, Rest of U.S.: Yes (acute & chronic)	Texas: Yes (acute) Rest of U.S.: No	Texas, Rest of U.S.: Yes (acute & chronic)	No	--
	Non-Listed	Yes	Texas, Rest of U.S.: Yes (acute & chronic)	Texas, Rest of U.S.: Yes (acute & chronic)	No	Texas, Rest of U.S.: Yes (acute & chronic)		
Estuarine/marine invertebrates	Listed	Yes	No	Texas, Rest of U.S.: Yes (acute)	No	Texas, Rest of U.S.: Yes (acute & chronic)	No	Exposure via wash-off may not be a complete exposure pathway given that the likelihood of livestock entering estuarine/marine bodies of water is uncertain
	Non-Listed	Yes	No	No	No	Texas, Rest of U.S.: Yes (chronic)		
Benthic (sediment-dwelling) invertebrates	Listed	Yes	RQs not calculated	Texas, Rest of U.S.: Yes (acute & chronic)	RQs not calculated	Texas, Rest of U.S.: Yes (acute & chronic)	No	RQs were calculated using pore water EECs and toxicity endpoints from water column exposure studies with freshwater invertebrates.
	Non-Listed	Yes		Texas, Rest of U.S.: Yes (acute & chronic)		Texas, Rest of U.S.: Yes (acute & chronic)		
Aquatic vascular plants	Listed	No	No	No	No	No	No	--
	Non-Listed	No	No	No	No	No		

Taxon	Status	Concern for risk from direct effects?*	Basis for Conclusion					
			RQ exceedance (type: acute and/or chronic)?				Incidents?	Comments
			Exposure pathways:					
			Runoff from land to which CAFO manure has been applied	Runoff from non-regulated small CAFOs (*i.e.*, < 300 animals)	Runoff from rangeland	Wash-off from treated livestock that enter bodies of water		
Aquatic non-vascular plants	Listed	NA	RQs not calculated				No	There is uncertainty associated with the risk conclusion as it is based on a qualitative analysis using toxicity data for a surrogate organophosphate insecticide.
	Non-Listed	No						

NA = not applicable; no listed aquatic non-vascular plants

* Direct or indirect effects to specific listed species have not been definitively determined; further investigation into temporal, geographical, and biological associations between the registered uses and affected taxa is needed before definitive effects determinations can be made.

Table 1-3. Summary of Direct Effects for Terrestrial Organisms

Taxon	Status	Concern for risk from direct effects?*	Basis for Conclusion						
			RQ exceedance (type: acute and/or chronic)?					Incidents?	Comments
			Exposure pathways:						
			Hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas	Contaminated bird carcasses	CAFO manure applied to land	Runoff from land to which CAFO manure has been applied	Contaminated fish		
Birds, reptiles, and terrestrial-phase amphibians	Listed	Yes	Texas, Rest of U.S.: Yes (acute)	Texas, Rest of U.S.: Yes (acute)	Texas, Rest of U.S.: Yes (acute)	NA	Texas, Rest of U.S.: Yes (acute; select species)	Yes	RQs were not calculated for chronic exposure due to the lack of avian chronic toxicity data. However, a comparison of EECs with an avian chronic toxicity endpoint for a surrogate organophosphate insecticide indicates that there may be a concern for risk from direct effects for exposure via: □ hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas; and □ contaminated fish.
	Non-Listed	Yes	Texas, Rest of U.S.: Yes (acute)	Texas, Rest of U.S.: Yes (acute)	Texas, Rest of U.S.: Yes (acute)		No		

Taxon	Status	Concern for risk from direct effects?*	Basis for Conclusion						
			RQ exceedance (type: acute and/or chronic)?					Incidents?	Comments
			Exposure pathways:						
			Hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas	**Contaminated bird carcasses**	**CAFO manure applied to land**	**Runoff from land to which CAFO manure has been applied**	**Contaminated fish**		
									There is uncertainty associated with these risk conclusions for chronic exposure given the use of a toxicity endpoint for a surrogate organophosphate insecticide.
Mammals	Listed	Yes	NA	Texas, Rest of U.S.: Yes (chronic)	Texas, Rest of U.S.: Yes (acute)	NA	No	No	--
	Non-Listed	Yes		Texas, Rest of U.S.: Yes (chronic)	No		No		
Terrestrial (upland and semi-aquatic) plants	Listed	No	RQs not calculated					No	There is uncertainty associated with the risk conclusions as they are based on a qualitative analysis using toxicity data for surrogate organophosphate insecticide.
	Non-Listed	No							
Honey bees (in-hive use)	Listed	NA**	NA					Yes	The risk conclusion is based on a qualitative analysis.
	Non-Listed	Yes							

NA = not applicable

* * Direct or indirect effects to specific listed species have not been definitively determined; further investigation into temporal, geographical, and biological associations between the registered uses and affected taxa is needed before definitive effects determinations can be made.

** Not applicable because the analysis for in-hive use only applies to honey bees which are non-listed.

2 Problem Formulation

The "EFED Ecological Risk Assessment Problem Formulation for Coumaphos Registration Review," which discussed the stressor and the tools and methods with which the Agency proposed to assess potential risk, was completed in 2008 (DP 347376; April 28, 2008). In order to avoid repetition of material previously provided, that document should be referred to for detailed information.

2.1 Summary of Activity Since 2008 Problem Formulation

Since the 2008 problem formulation, no new screening-level ecological risk assessments for coumaphos were completed. However, the following studies have been submitted and reviewed: a Tier II aquatic vascular plant study with *Lemna gibba* (MRID 48322801); a Tier II aquatic non-vascular plant study with the green alga *Pseudokirchneriella subcapitata* (MRID 48322802); and an adsorption/desorption study for coumaphos and its degradate coumaphos oxon in four soil types (MRID 45721401). In addition, an aerobic soil metabolism study with coumaphos oxon in two Texas soils was submitted to the Agency (MRID 48705501). The study with *L. gibba* yielded a EC_{50} of >166 µg a.i./L and a NOAEC of 166 µg a.i./L and was classified as "supplemental" due a guideline deviation (*i.e.*, a the number of plants per replicate was lower than recommended). The study with *P. subcapitata* was classified as "invalid" because the solvent had a stimulatory effect that could have masked the true effects of coumaphos. An additional aquatic non-vascular plant study for coumaphos was not requested based on an analysis presented in an EFED memo (DP 406398, October 31, 2012; see **Section 5.1.6** for additional details). The adsorption/desorption study (MRID 45721401) for coumaphos and its degradate coumaphos oxon was classified as "partially acceptable" due to the unresolved issue of using a biocide as a soil sterilization procedure. The aerobic soil metabolism study (MRID 48705501) was classified as "supplemental" due to a soil extraction procedure that may not be adequate to remove all identifiable residues from soil.

The 2008 problem formulation indicated that the Registration Review ecological risk assessment would estimate risk as a result of exposure from the application of coumaphos to cattle and exposure from the application of bioremediated spent dip vat solutions to land. Risk from the former exposure pathway would be estimated using registrant-submitted data for estimating wash-off from cow hides.

A 2007 Label Data Report[2] by the Biological and Economic Analysis Division (BEAD) indicates that a single label (Co-Ral® Flowable Insecticide; Reg. No. 011556-98) allows for application of coumaphos to livestock via dip vat. This label specifies that use is restricted to "employees of the U.S. Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS) who are enrolled in the USDA-APHIS cholinesterase monitoring program." Furthermore, the label states that:

> "The Agency requires that spent dip-vat solution be bioremediated, and recommends the bioremediation method developed by the USDA. The treated solution must be transferred

[2] Date: September, 2007

to shallow, concrete-lined evaporation ponds for further degradation. The evaporation ponds must be constructed to prevent overflow or flooding during wet seasons and must be lined with reinforced concrete. Dried sludge generated in the evaporation ponds must not be applied to agricultural land and should be disposed according to solid waste disposal regulations established by your Local and/or State Environmental Control Agency. Questions concerning the disposal of spent solution should be directed to the waste representative at the nearest EPA Regional Office."

In the 2008 problem formulation, the Agency requested that stakeholders provide information to refine the ecological risk assessment. APHIS responded to the request for "any current information pertaining to disposal of bioremediated solution (*i.e.*, dried sludge generated in the evaporation ponds" as follows:

"There are three evaporation ponds used by CFTEP[3] officials in Texas. One evaporation pond is located in each of the three following cities: Mission, Eagle Pass, and Laredo. Due to the small amount of sediment in the Mission and Eagle Pass evaporation ponds, it has not been necessary to dispose of any sediment from those locations. A sample of the dried sediment from the evaporation pond in Mission was sent to the National Veterinary Services Laboratory (NVSL,) in Ames, Iowa for testing. The test indicated that no coumaphos was present. A small amount of dried sediment (approximately 12 feed sacks) was cleaned out of the Laredo pit, placed into a sack, and disposed of at an approved landfill. In order to support APHIS' belief that the disposal of Co-Ral used in the CFTEP does not contribute to water contamination, APHIS would like to take this opportunity to point to USDA's PDP monitoring data for finished (treated) or untreated water. In 2005 and 2006, no coumaphos was detected in finished water or untreated water." (DP 347373)

Given that dried sludge generated in evaporation ponds containing bioremediated dip vat solution is discarded in a landfill by USDA-APHIS, EFED concludes that exposure via application of bioremediated spent dip vat solutions to land is not a complete exposure pathway. Therefore, risk as a result of exposure from the application of bioremediated spent dip vat solutions to land is not estimated or characterized in the present assessment.

According to the 2008 problem formulation, the indoor use of coumaphos (*e.g.*, to treat swine bedding) and the placement of coumaphos-treated strips in bee hives would not be considered in the Registration Review ecological risk assessment because they do not provide complete routes of exposure to surface waters or to the surrounding non-target terrestrial environment. However, in a November 1, 2012 memo (DP 393874; November 1, 2012), EFED reviewed the 2008 problem formulation to determine whether additional pollinator studies were needed to assess the potential for risk due to the registered use of coumaphos as an in-hive insecticide to control varroa mites and the small hive beetle.

The EFED memo stated: "There are two scenarios when the safety of a pesticide applied to an animal is a factor. In the first scenario, when a pesticide is applied to livestock, such as cattle, swine, or poultry, no safety data are required to determine if the pesticide may pose a threat to the health of the livestock. The assumption made in the absence of data is that a registrant would

[3] Cattle Fever Tick Eradication Program

not have a market for a product that is not safe for the livestock it is meant to protect. However, residue data are required for meat products of the livestock to ensure that tolerances established for the protection of human health are not exceeded. In the second scenario, when a pesticide is used as a spot-on product for parasite control on a companion animal, such as a dog or cat, safety data are required to determine if the pesticide may pose a threat to the health of the companion animal (OCSPP 870.7200)."

The EFED memo then presented a 3-step analysis to assess the potential for risk to bees from the in-hive use of coumaphos. As a result of this three-step analysis, the memo concluded that EFED is able to qualitatively assess hazard (toxicity only) to honey bee colonies. Specifically, there is a potential for hazard to individuals of honey bee colonies, as well as hive stability, as a result of coumaphos use. The memo indicated that EFED may also be able to quantitatively characterize risk (integration of toxicity and exposure) in the future Registration Review ecological risk assessment using the information described in the memo. Therefore, based on the use pattern and exposure scenario of coumaphos, EFED did not recommend requesting any further data for the effects of coumaphos on honey bees at that time. Since the writing of the memo, EFED has examined the available data and concluded that risk to bees from in-hive use of coumaphos in impregnated strips can only be assessed qualitatively due to the lack of data that is suitable for a quantitative approach.

2.2 Previous Ecological Risk Assessments

No ecological risk assessments for coumaphos have been conducted since the 2008 EFED problem formulation (DP 347376; April 28, 2008). The problem formulation presented the following ecological risk conclusions based on previous ecological risk assessments[4] conducted for coumaphos:

- Avian risk from acute exposure: Coumaphos is expected to pose acute risk to birds. Birds may be subject to primary exposure via ingestion of hair and skin debris from treated cattle or secondary exposure via ingestion of birds killed by the pesticide, and contaminated with the pesticide.
- Avian risk from chronic exposure: The Agency concluded that avian reproduction studies were not required for coumaphos. Such studies may be required when birds are likely to be exposed to a pesticide repeatedly or continuously. According to the 1996 RED

[4] Finalization of Interim Reregistration Eligibility Decisions (IREDs) and Interim Tolerance Reassessment and Risk Management Decisions (TREDs) for the Organophosphate Pesticides, and Completion of the Tolerance Reassessment and Reregistration Eligibility Process for the Organophosphate Pesticides. July 3 1,2006. EPA 73 8-R-00- 10.
EFED Drinking Water and Ecological Risk Review for Coumaphos (036501) IR-4 Use on Beehives. DP 315770. May 16, 2006
Screening Level Aquatic Exposure Assessment for the Use of Coumaphos in the Pacific Northwest and California to Treat Cattle via Spray and Vat Dips for the Endangered Species (ES) Consultation Package. DP 303298. June 6, 2004.
US EPA Reregistration Eligibility Decision (RED) for Coumaphos. August 1996. EPA 738 R-96-014.
EFED Review for Coumaphos RED. September 19, 1994. (EFED's environmental fate and ecological effects sections for the Cournaphos 1996 RED)

document's assessment of acute risk, "if there were significant coumaphos exposure to birds, they would be killed before chronic effects could occur."

- Mammalian risk from acute exposure: Coumaphos is not expected to pose a risk to endangered or non-endangered mammals because the limited use pattern of coumaphos, *i.e.*, treatment of cattle in confined areas, is not expected to result in significant exposure.
- Aquatic organism risk: Based on the Agency analysis, coumaphos usage on cattle is expected to pose an acute risk to aquatic invertebrates. Coumaphos is not expected to pose acute or chronic risks to listed or non-listed fish.

It should be noted that these risk conclusions were revisited in the present assessment to ensure their accuracy in the context of current available data and risk assessment methods.

2.3 Mode of Action

Coumaphos (O,O-diethyl O-3-chloro-4-methyl-2-oxo-21-H benzopyran-7-yl phosphorothioate) is an insecticide/acaricide that belongs to the organophosphate class of pesticides. The toxic mode of action of coumaphos is the inhibition of acetyl cholinesterase resulting in repeated nerve firing due to build up of acetylcholine, hyperexcitation, and eventually death.

2.4 Use Characteristics

Coumaphos was first registered in the United States in 1958 for use as an insecticide. A dust formulation, the first end-use product, was registered the following year for the control of insects on cattle. Currently, coumaphos is registered for the control of flies (face fly, horn fly), ticks, lice, mites (scabies mite) and screw worms on livestock (*e.g.*, dairy cattle, horses, sheep, and swine) and swine bedding and to control varroa mites and small hive beetles in bee hives. Coumaphos is formulated as a dust, emulsifiable concentrate, and flowable concentrate and is applied directly to livestock via dip vat, low and high-pressure hand wand, back rubber/oiler, mechanical duster, dust bag or shaker can.

This Registration Review ecological risk assessment used coumaphos application information as presented in the 2008 EFED problem formulation (DP 347376; April 28, 2008) and associated label data report (Label Use Information System report; LUIS) dated September 13, 2007 as well as additional information provided by BEAD (*e.g.*, volume of solution mixed per animal to convert rate in lb a.i./gal as specified on some labels to lb a.i./animal). There have been no new uses of coumaphos registered since the 2008 EFED problem formulation.

Based on usage information presented in the 2008 EFED problem formulation, the largest livestock use of coumaphos is for cattle (59,000 lb a.i./yr for cattle vs. 12,000 lb a.i./yr for other livestock; DP 347376, April 28, 2008). Therefore, this assessment was conducted using application rates for cattle. Maximum application rates (single and annual), minimum application intervals, and application methods/equipment for cattle are provided in **Table 2-1**. It should be noted that labels for coumaphos typically do not specify a maximum annual application rate. Therefore, maximum annual application rates were calculated for cattle using the maximum single application rate and annual number of applications.

The maximum single application rate (*i.e.*, 0.027 lb a.i./animal for dip vat[5]) and the maximum annual application rate (*i.e.*, 0.063 lb a.i./animal for spray[6]) for cattle are for the end-use product Co-Ral® Flowable Insecticide (EPA Reg. no. 11556-98). Use of this product is restricted to employees of the USDA-APHIS who are enrolled in the USDA-APHIS cholinesterase monitoring program. The USDA's Cattle Fever Tick Eradication Program (CFTEP) uses this product solely in Texas. As a result, these maximum application rates were used to assess risk to non-target species in Texas only. The next highest maximum single application rate (*i.e.*, 0.01 lb a.i./A for dust or spray[7]) and maximum annual application rate for cattle (*i.e.*, 0.05 lb a.i./animal for back rubbers[8]) were used to assess risk to non-target species in the rest of the United States.

[5] 2 applications @ 0.027 lb a.i./animal = 0.054 lb a.i./animal/yr for dip vat
[6] 3 applications @ 0.021 lb a.i./animal = 0.063 lb a.i./animal/yr for spray
[7] 3 applications @ 0.01 lb a.i./animal = 0.03 lb a.i./animal/yr for spray or dust
[8] 6 applications @ 0.00829 lb a.i./animal = 0.05 lb a.i./animal/yr for back rubbers

Table 2-1. Application Information for Registered Uses of Coumaphos: Cattle[a,b,c]

Use	Application Method/ Equipment	Form. (% a.i.)	Maximum Single Application Rate (lb a.i./ animal)	Maximum Single Application Rate (lb a.i./ gal)	Annual Number of Applications	Minimum Application Interval (Days)	Maximum Annual Application Rate[d] (lb a.i./animal)	Comments
Beef/range/ feeder cattle; dairy cattle	Back rubbers	EC (11.6)	0.00829 (avg.; est.)	0.0762	3.5 (avg.)	NS or AS	0.029	--
	Back rubbers	EC (6.2)	0.00829 (avg.; est.)	0.0385	6 or NS	10 or NS	**0.050**	Represents **maximum** annual application rate for the U.S. with the exception of Texas
	Dip vat	FC (42)	**0.027 (est.)**	0.0255[e]	2	10	0.054	EPA Reg No. 11556-98; use restricted to employees of the USDA-APHIS Represents **maximum** annual application rate for Texas
	Dust	Dust (1)	**0.01**		3 (avg.)	NS	0.03	Represents **maximum** single application rate for the U.S. with the exception of Texas
	Dust	Dust (1)	0.0013		3 (avg.)	10 or 14	0.0039	--
	Dust	Dust (1)	0.000625		3 (avg.)	1	0.0019	--
	Spray	FC (42)	0.021 (est.)	0.021	3 (avg.)	10	**0.063**	EPA Reg No. 11556-98; use restricted to employees of the USDA-APHIS Represents **maximum** single application rate for Texas
	Spray	EC (6.2)	**0.01 (est.)**	0.01	3 (avg.)	10	0.03	Represents **maximum** single application rate for the U.S. with the exception of Texas
	Spray	EC (11.6)	0.00978 (est.)	0.00978	3 (avg.)	AS	0.029	--
	Ear Tag	IM (20)	0.00625		3 (avg.)	NS	0.019	--

AS = as needed; avg. = average; est. = estimated (by BEAD); NS = not specified; EM = emulsifiable concentrate; FC = flowable concentrate; Form. = formulation; IM = impregnated material; Max. = Maximum; Min. = Minimum; NA = not applicable; RTU = ready to use

[a] label data report (Label Use Information System report; LUIS) dated September 13, 2007

[b] application information for maximum single and annual rates in BOLD

[c] estimated/average values provided by BEAD

[d] not specified on label; calculated based on maximum single application rate and maximum annual number of applications

[e] 0.306% suspension

2.5 Conceptual Model

2.5.1 Risk Hypotheses

As stated in the 2008 EFED problem formulation (DP 347376; April 28, 2008), this Registration Review ecological risk assessment tests the following risk hypothesis:

Non-target terrestrial and aquatic animals and plants are at risk of direct and indirect effects resulting from labeled uses or land disposal of coumaphos.

2.5.2 Exposure Pathways of Concern

This Registration Review ecological risk assessment considers potential exposure to coumaphos as a result of:

- the application of coumaphos to livestock and
- in-hive use of coumaphos.

The latter exposure pathway of concern is considered only for honey bees. Potential exposure from the application of bioremediated spent dip vat solutions to land is not considered in the assessment because it is not a complete exposure pathway (see **Section 2.1** for rationale).

The 2008 EFED problem formulation (DP 347376; April 28, 2008) provided a general conceptual model of the fate/transport and effects of coumaphos in the environment for the application of coumaphos to livestock. Since coumaphos has not been detected in groundwater, exposure via irrigation water containing coumaphos was not considered in this assessment. **Table 2-2** provides a list of the exposure pathways that are considered in this assessment for the application of coumaphos to livestock.

Table 2-2. Exposure Pathways by Taxon for Application of Coumaphos to Livestock

Taxon	Exposure Pathways Assessed
Birds	- contact with/ingestion of hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas - ingestion of contaminated bird carcasses - ingestion of food items on land receiving manure from Concentrated Animal Feeding Operations (CAFOs) - ingestion of contaminated fish
Mammals	- ingestion of contaminated bird carcasses - ingestion of food items on land receiving manure from CAFOs - ingestion of contaminated fish
Terrestrial plants*	- uptake from CAFO manure applied to land - uptake from soil receiving runoff from land to which manure from CAFOs has been applied
Fish, aquatic invertebrates, and aquatic plants	- uptake from surface waters receiving runoff from land to which contaminated manure has been applied - uptake from surface waters receiving runoff from non-regulated small CAFOs (*i.e.*, < 300 animals) - uptake from surface waters receiving runoff from rangeland where treated livestock graze - uptake from surface waters into which treated livestock wade (*i.e.*, wash-off from treated livestock that enter bodies of water)

* Given the low application rates calculated for runoff from rangeland where treated livestock graze (see **Table 4-6**), uptake from soil receiving runoff from rangeland where treated livestock graze was not considered to be an exposure pathway of consequence.

2.5.3 Stressors of Concern

2.5.3.1 Terrestrial Assessment

The stressor of concern for the terrestrial portion of this ecological risk assessment is coumaphos.

2.5.3.2 Aquatic Assessment

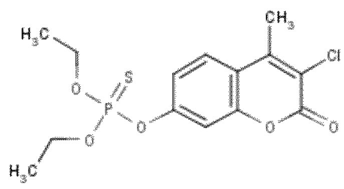
Coumaphoxon was detected in an aqueous photodegradation study at a maximum of 10.2% of applied chemical (MRIDs 42764101 and 43103901). Therefore, the stressors of concern for the aquatic portion of this assessment are coumaphos and its oxygen analog coumaphoxon (O,O-diethyl O-3-chloro-4-methyl-2-oxo-2-H-1-benzopyran-7-yl phosphate).

3 Fate and Transport Characterization

Coumaphos (O-[3-chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl] O,O-diethyl phosphorothioate) is an organophosphate insecticide/acaricide. Physical, chemical and environmental fate properties of coumaphos are presented in **Table 3-1**. Coumaphos has a relatively low vapor pressure (1.0×10^{-7} mm Hg) and Henry's Law constant (4.62×10^{-9} atm·m^3/mol), which suggest that volatilization is not expected to be a major route of dissipation from soil and water. A limited environmental fate database for coumaphos indicates that it is persistent (DT_{50} of >1 year in aerobic soil) and slightly mobile to hardly mobile (K_{foc} of 1874 to 10297 L/Kg) in soil according to FAO classification of mobility in soil (FAO, 2000). Hydrolysis is also not a significant route of dissipation for coumaphos. In two field dissipation studies where coumaphos was applied at 300 ppm with and without incorporation, the half-life of coumaphos was determined to be 118 and 185 days. Although the soil was not sampled deep enough to define the extent of leaching, samples taken at the 6- to 12-inch depth (the deepest layer sampled) contained between 25-375 ppm at 32 weeks and 5-69 ppm at 52 weeks post-treatment. The terrestrial field dissipation studies indicate that coumaphos is relatively persistent, as was also indicated by the aerobic soil metabolism study.

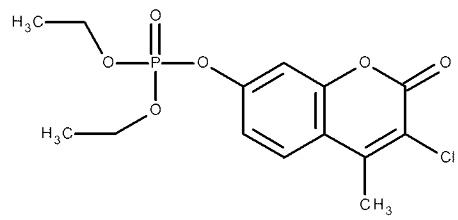
The major pathway of coumaphos degradation appears to be photodegradation in water (DT_{50} of 33 hours). A major degradate, oxygen analog coumaphoxon, was detected in an aqueous photodegradation study at a maximum of 10.2% of applied chemical. Limited environmental fate data for coumaphoxon (**Table 3-2**) suggest that it is not a persistent compound in the terrestrial environment (aerobic soil metabolism DT_{50} of 0.49 to 2.27 days) and that it is mobile to moderately mobile (K_{foc} of 767 to 5810 L/Kg) in soil according to FAO classification of mobility in soil (FAO, 2000). Total coumaphos residues accumulated in bluegill sunfish with a maximum bioconcentration factor of 541X in whole fish during 30 days of exposure to coumaphos. Accumulated coumaphos residues were depurated rapidly, with 95% elimination after 1 day in untreated water.

Table 3-1. Physical, Chemical and Environmental Fate Properties of Coumaphos

Parameter	Value	Source
Common name	Coumaphos	USEPA, 2007
Chemical name	3-chloro-7- diethoxyphosphinothioyloxy-4-methylcoumarin	
CAS #	56-72-4	
CAS Name	*O*-(3-chloro-4-methyl-2-oxo-2*H*-1-benzopyran-7-yl) *O,O*-diethyl phosphorothioate	
Empirical formula	$C_{14}H_{16}ClO_5PS$	
Structure		
Molecular mass	362.5	USEPA, 2007
Water solubility (20_C)	20 mg/L	USEPA, 2007
Vapor pressure (20_C)	1.0E-07mm Hg	USEPA, 2007
Henry's Law Constant	2.62E-09 atm m^3/mol	Estimated
Octanol/water partition coefficient (Log K_{ow})	4.3	TOXNET
Hydrolysis (DT_{50})	Stable at pH 5,7 and 9	USEPA, 1993a MRIDs 00150197 00159928
Direct Aqueous Photolysis (DT_{50})	1.38 days	MRID 42764101 MRID 43103901
Soil Photolysis	24 days 40 days	MRID 42920301 MRID 43167401
Aerobic Soil Metabolism (DT_{50})	Stable[a]	MRID 40518701
Anaerobic Soil Metabolism (DT_{50})	No Data	---
Aerobic Aquatic Metabolism (DT_{50})	No Data	---
Soil Partition Coefficient (K_f)	57.3 L kg^{-1} for Sand 26.0 L kg^{-1} for Sandy Clay Loam 65.2 L kg^{-1} for Clay Loam 65.9 L kg^{-1} for Clay Loam	MRID 45721401
Soil Partition Coefficient (K_{foc})	5257 L kg o.c.$^{-1}$ for Sand 6190 L kg o.c.$^{-1}$ for Sandy Clay Loam 1874 L kg o.c.$^{-1}$ for Clay Loam 10297 L kg o.c.$^{-1}$ for Clay Loam	
Mobility-Leaching	Column Study (Aged sample) Immobile	MRID 00163806
Terrestrial Field Dissipation (DT_{50})	185 days (in the upper 6 inches of soil)	MRID 00115166
Bioconcentration (BCFs)	541X Whole Fish	MRIDs 00115168 and 00150619

[a] Since the revised DT_{50} of 2752 days (calculated using the NAFTA Guidance, USEPA, 2012a) is well beyond the duration of the study (365 days), the aerobic soil half-life is considered as stable.

Table 3-2. Physical, Chemical and Environmental Fate Properties of Coumaphoxon

Parameter	Value	Source
Chemical Structure		MRID 48705501
Chemical Name	Coumaphos Oxon	MRID 48705501
CAS Name	O-(3-Chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl)O,O-diethyl phosphate	MRID 48705501
IUPAC	3-Chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl diethyl phosphate	MRID 48705501
Molecular Weight	346.71	EPISUITE 4.1
Solubility (25° C)	31.61 mg/L (Based on Log K_{OW} Method) 210.46 mg/L (Fragment Method)	EPISUITE 4.1
Vapor pressure (25_C)	7.68×10^{-8} mm Hg	EPISUITE 4.1
Henry's Law Constant	1.10×10^{-9}atm m^3/mol	EPISUITE 4.1
Octanol/water partition coefficient (Log K_{ow})	2.71	EPISUITE 4.1
Soil Partition Coefficient (K_f)	11.4 L^{-1} kg for Sand 24.4 L kg^{-1} for Sandy Clay Loam 26.7 L^{-1} kg for Clay Loam 26.0 L^{-1} kg for Clay Loam	MRID 45721401[a]
Soil Partition Coefficient (K_{foc})	1046 L kg o.c.$^{-1}$ for Sand 5810 L kg o.c.$^{-1}$ for Sandy Clay Loam 767 L kg o.c.$^{-1}$ for Clay Loam 4063 L kg o.c.$^{-1}$ for Clay Loam	
	198.4 L kg	EPISUITE
Aerobic soil Metabolism (DT_{50})	Silt soil 0.49 days Loamy Sand soil 2.27 days	MRID 48705501

[a] Soil partition coefficient values reported in MRID 45721401 are problematic. In a recent study, there was a substantial degradation (0 – 92%) of the coumaphoxon during the 24-hr equilibration period (personal communication-via email on 6/24/2013) possibly due to hydrolysis.

4 Exposure Assessment

4.1 Calculation of Application Rates

During a rain event, a certain fraction of coumaphos wash-off from treated cattle can be potentially adsorbed into manure as well as transported as runoff from CAFOs and pasture/rangeland. Estimated exposure concentrations (EECs) from runoff and wash-off were calculated for Texas and the rest of the U.S. using maximum application rates for cattle (see **Section 2.4** for application rates and rationale) as well as data from acceptable registrant-submitted studies quantifying the fraction of coumaphos that becomes available for exposure after soaking a cow hide in water (*i.e.*, wash-off fraction; **Table 4-1**).

In registrant-submitted wash-off studies, fresh cow hides were treated with either Co-Ral® 11.6% emulsifiable liquid (MRID 42512601) or Co-Ral® 25% wettable powder (MRID 42512602) and then dried for 0.5, 3, or 24 hours. The wash-off fraction was measured after hides had been soaked in water for 0.5, 1, 2, or 4 hours. Results of these studies indicate that wash-off fraction is inversely related to drying time and dependent upon the formulation (**Table 4-1**) but not affected by soaking time (data not shown). Although not the most conservative, wash-off fractions for the 24-hour drying time were used in this assessment because they represent a reasonable time frame after application for a treated cow to be caught in a rainstorm or enter a body of water.

Table 4-1. Percent Wash-Off for Different Formulations of Coumaphos at Different Drying Times (MRIDs 42512601 and 42512602)

Formulation (%)	Drying Time (hrs)	Wash-Off Fraction	Comment
Emulsifiable powder/concentrate (11.6)	0.5	0.116	Represents formulation associated with maximum application rates for the U.S. with the exception of Texas (back rubbers and spray)
	3	0.046	
	24	0.027	
Wettable powder/flowable concentrate (25)	0.5	0.38	Represents formulation associated with maximum application rates for Texas (dip vat and spray)
	3	0.21	
	24	0.02	

To accurately characterize the potential environmental exposure pathways, selecting the appropriate livestock management system and various exposure pathway scenarios is necessary. Several scenarios were considered to estimate the application rate for coumaphos and potential exposure to coumaphos for terrestrial and aquatic environments. The following scenarios and example calculations of application rates are based on spray (Texas) or back rubber (rest of the U.S.) application on cattle. **Table 4-2** provides application rates for various scenarios.

Table 4-2. Estimated Coumaphos Application Rates for Various Scenarios[a]

Sources of a.i. from Application Scenario	Wash-Off Fraction	Maximum Single Application Rate (lb/A)	Number of Applications/ Year	Maximum Annual Application Rate (lb/A)
Texas: Spray Application (42% flowable concentrate)				
CAFO manure applied to land[b]	No incorporation of manure into soil			
	0.02	0.015	1[c]	0.015
	Incorporation of manure into soil within a day			
	0.02	0.009	1[c]	0.009
Runoff from small non-regulated CAFO	0.02	0.008	12[d]	0.096
Runoff from range land	0.02	0.00013	3	0.0004
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)				
CAFO manure applied to land[b]	No incorporation of manure into soil			
	0.027	0.0092	1[c]	0.0092
	Incorporation of manure into soil within a day			
	0.027	0.0051	1[c]	0.0051
Runoff from small non-regulated CAFO	0.027	0.0050	12[d]	0.0603
Runoff from range land	0.027	0.0001	3	0.0003

AU = animal unit

[a] Sample calculations provided in **Sections 4.1.1** to **4.1.3**

[b] Application rate of coumaphos depends on nutrient management and application method of manure.
[c] Application rate can be split based on total nitrogen (TN) requirement during the growing season.
[d] Three or two applications/stocking period; maximum four stocking periods based on http://www.epa.gov/agriculture/ag101/beefproducts.html

4.1.1 Example Calculation: Manure from CAFOs (Concentrated Animal Feeding Operation)

Manure used as a soil amendment/organic fertilizer could be a potential source for pesticides that are embedded in it from wash-off from treated livestock. Since coumaphos is stable in soil, degradation was not considered. Application rate of coumaphos was estimated based on dry weight of manure application for crop production. The following steps were used to calculate the application rate of coumaphos.

Step 1: ***Total dry weight of manure (DM)/AU(animal unit) /year***

DM = 8.5 lb solid in manure [ASAE, 2003] /AU x 365 days = 3103 lb dry manure/AU/year or 1.55 tons/AU/year

Step 2: ***Active ingredient in manure (AM) lb a.i./AU***

AM = (A x F x S x W x PA) lb a.i./AU/year
Where:
A = application rate: 0.021 lb/AU for spray application (**Table 2-1**)
F = frequency of application: 3/AU/year (**Table 2-1**)
S = # of stocking/year: 4 (Based on 90-120 days stocking period for cattle in feedlot[9])
W = wash-off fraction: 0.02 (Texas; coumaphos formulations restricted to APHIS) or 0.027 (for non-restricted coumaphos formulations; rest of the U.S.) (MRIDs 42512601 and 42512602)
PA = potential fraction of coumaphos washed off of cattle during a rain event that can come into contact with and adsorb to manure: 0.36 (assumed based on EPISUITE estimate for adsorption into sludge)

Sample calculation is based on Co-Ral® Flowable Insecticide:
AM = (0.021 x 3 x 4 x 0.02 x 0.36) = 0.0018 a.i. lb/AU

Step 3: ***Active ingredient in manure (lb a.i./ton)***

(0.0018 lb a.i./1.55 ton manure) = 0.0012 lbs a.i./ton dry manure

Step 4: ***Total nitrogen production (TN) per animal (lbs TN/AU/year)***

TN = (N x L x V x D) lbs TN/AU/year
Where:
N = nitrogen content in manure per AU (TN lb/AU) (ASABE, 2003)

[9] http://www.epa.gov/agriculture/ag101/beefproducts.html

L = average fraction of N retained during storage and handling: 0.5 (Table 11.5, USDA, 2008). The range of N retention varies from 40 to 60 for arid region and 55 to 70 in humid region.

V= Fraction of N loss due to volatilization: 0.1 (based on next day incorporation into soil after application in warm wet soil condition) to 0.5 (based on no incorporation for seven days into soil) (Table 11.6, USDA, 2006). The range of volatility loss varies from 50 percent in warn dry soil to 10 percent in cool wet soil. In addition, volatility loss may also depend on method of manure application (i.e. 5% and 25% volatilization loss from injection and sprinkling methods respectively. Since there is an inverse relationship between volatilization loss and application rate of manure, the highest and lowest volatilization rate was considered to calculate application rate of coumaphos.

D = 365 of days /year

Sample calculation:

TN = (0.34 x 0.5 x 0.5 x 365) = 31 lbs TN in manure/AU/year [For no incorporation for seven days under warm dry soil scenario]

Step 5: ***Total N in manure (lb/ton manure)***

(31 lbs TN/1.55 ton manure) = 20 lbs TN/ton manure/AU

Step 6: ***Application rate of manure (ton/acre)***

In general, the application rate of manure is based on TN recommendation for crop types. For example, 250 lb TN/acre per year requires for growing warm season perennial grass in Texas[10].

Sample calculation:

(250 lbs TN/acre) x (1 ton Manure /20 lbs TN)

12.5 tons manure/acre require for growing perennial grass in Texas

Step 7: ***Application rate of active ingredient (lb/acre)***

(0.0012 lbs a.i/ton) x (12.5 tons manure/acre) = 0.015 lbs a.i./acre

Therefore, the application rate of 0.015 lbs a.i/A is based on 2% coumaphos wash-off from treated cattle.

4.1.2 Example Calculation: Non-Regulated Small CAFO ≤ 300 cattle

Runoff of washed-off coumaphos from treated cattle could be a major contributor from an open non-regulated feedlot. Application rate was estimated from runoff contribution based on wash-off fraction of coumaphos and animal density per acre. The following equation was used in calculating application rate:

[10] Stichles and McFarland, http://agrilifeextension.tamu.edu/

Application Rate (AR) of active Ingredient (lb/A)
AR (lb a.i./A) = (A x F x S x C x W x PR X FF)
Where:
A = application rate: 0.021 a.i. lb/AU (spray application)
F = frequency of application: 3 (spray application)
S = # of stocking/year: 4 (Based on 90-120 days stocking period for cattle in feedlot[11])
C = # of AU in feedlot: 300 (Maximum cattle density in non-regulated CAFOs). The amount of pen space per animal (stocking density) depends upon climate and whether the lots are paved (50 to 75 ft^2/animal) or earthen (250 to 500 ft^2/animal). Others report stocking densities to range between 150 to 300 ft^2/animal.
W = wash-off fraction: 0.02 (Texas) or 0.027 (rest of the U.S.) (MRIDs 42512601 and 42512602)
PR = potential removal through adsorption of coumaphos into manure: 0.64 (1-0.36) (based on EPISUITE estimate for adsorption of coumaphos into sludge)
FF = fraction of feedlot for 10 hectare scenario: 0.1 (based on 3 acres (1 ha) for 300 AU, where density of 100 cattle/acre; Murphy and Harner, 2006).

Sample calculation:
AR = (0.021 x 3 x 4 x 300 x 0.02 x 0.64 x 0.1) = 0.0096 lb a.i./A/yr

4.1.3 Example Calculation: Cattle Grazing in Rangeland

Runoff of washed-off coumaphos from treated cattle could be a major contributor from treated cattle grazing on rangeland. Application rate was estimated from runoff contribution based on wash-off of coumaphos and animals stocking rate per acre.

Application Rate (AR) of active Ingredient (lbs/Acre)
AR = (A x F x C x W)
Where:
A = application rate: 0.021 lb/AU (spray application)
F = frequency of application: 3 (spray application)
C = # of AU in pasture/land: 0.3 was based on 800 lbs cattle (Pratt and Rasmaussan, 2001). There is an inverse relationship between weight of cattle and number of AU in pasture/land. Numbers of AU on pasture land also depends on the size of cattle and forage production.
W = wash-off fraction: 0.02 (Texas) or 0.027 (rest of the U.S.) (MRIDs 42512601 and 42512602)

Sample calculation:
AR = (0.021 x 3 x 0.3 x 0.02) = 0.0004 lb/A

4.2 Aquatic Exposure

Exposure of aquatic organisms to coumaphos could occur as a result of:

[11] http://www.epa.gov/agriculture/ag101/beefproducts.html

- uptake from surface waters receiving runoff from land to which contaminated manure has been applied;
- uptake from surface waters receiving runoff from small CAFOs (*i.e.*, < 300 animals);
- uptake from surface waters receiving runoff from rangeland where treated livestock graze; and
- uptake from surface waters into which treated livestock wade (*i.e.*, wash-off from treated livestock entering bodies of water).

As stated in the problem formulation, the stressors of concern for aquatic exposure are coumaphos and its oxygen analog coumaphoxon. There are no data available for the toxicity of coumaphoxon to aquatic organisms. However, a comparative acute toxicity study by Tsuda et al. (1997) with organophosphate insecticides – diazinon, malathion, fenitrothion, and EPN) and their oxygen analogs – diazinon oxon, malaoxon, fenitrothion oxon, and EPN oxon, respectively – generally indicates that the oxidation product is more toxic than the parent to fish (**Table 4-3**). In contrast, enzymatic conversion to the oxon dominates hydrolysis of any of the ester linkages in insects suggesting that the oxon and parent are equally toxic to these organisms (Fest and Schmidt, 1973). Therefore, the acute toxicity of coumaphos was assumed to be equivalent to the acute toxicity of its oxidation product for aquatic invertebrates. Equivalent toxicity of parent and oxidation product was also assumed for aquatic plants due to the lack of toxicity data. As a result, different approaches were taken to calculate aquatic acute EECs for fish and aquatic invertebrates and plants. For fish, a toxic equivalency (TEQ) approach was taken using the average toxic equivalency factor calculated for the four organophosphate insecticides tested by Tsuda et al. (1997) (*i.e.*, 7.25; see **Table 4-3**) since all the data came from the same laboratory, thereby eliminating inter-laboratory variability. The equations for the TEQ approach are provided in **Table 4-4**. Specifically, surface water peak EECs for coumaphos were modeled via PRZM/EXAMS and then adjusted for formation and toxicity of the oxidation product to yield a parent equivalent peak EEC (parent coumaphos + degradate coumaphoxon). For aquatic invertebrates and plants, the total toxic equivalent residue (TTER) approach, which is similar to the total toxic residue approach, was taken using the equation in **Table 4-4** which yields peak EECs (parent coumaphos + degradate coumaphoxon) that are equal to the surface water peak EECs for coumaphos modeled via PRZM/EXAMS.

Since comparative chronic toxicity studies are not available for parent organophosphate insecticides and their oxidation products, a TTER approach was used for fish and aquatic invertebrates using the equation in **Table 4-4** which yields total chronic EECs that are equal to surface water chronic EECs for coumaphos modeled via PRZM/EXAMS.

Table 4-3. Calculation of Toxic Equivalency Factors (TEQs) for Four Organophosphate Insecticides

Parent (MW) Oxidation Product (MW)	48-hr LC_{50}[a]				TEQ Parent 48-hr LC_{50} (µmol/L): Oxidation Product LC_{50} (µmol/L)
	Parent		Oxidation Product		
	mg/L	µmol/L	mg/L	µmol/L	
Diazinon (304.35) Diazinon oxon (288.28)	4.4	14.46	0.22	0.76	18.94
Malathion (330.4) Malaoxon (314.29)	1.8	5.45	0.28	0.89	6.12

Parent (MW) Oxidation Product (MW)	48-hr LC_{50}[a]				TEQ Parent 48-hr LC_{50} (µmol/L): Oxidation Product LC_{50} (µmol/L)
	Parent		Oxidation Product		
	mg/L	µmol/L	mg/L	µmol/L	
Fenitrothion (227.23) Fenitrothion oxon (261.17)	3.5	12.62	6.8	26.04	0.48
EPN (323.3) EPN oxon (307.24)	4.4	1.79	0.16	0.52	3.44
				Average	7.25

MW = molecular weight (g/mol)
[a] based on data from Tsuda et al., 1997

Table 4-4. Equations for Calculating Aquatic Total Estimated Environmental Concentrations (EECs) and Risk Quotients (RQs)

Exposure Duration	Taxon	Approach	$EEC_{(parent+oxon)}$	Acute RQ
Acute	Fish	Toxic equivalency	= (% $formed_{(parent)}$*Peak $EEC_{(parent)}$*$TEQ_{(parent)}$) + (% $formed_{(oxon)}$*Peak $EEC_{(parent)}$*$TEQ_{(oxon)}$) = (0.9*Peak $EEC_{(parent)}$*1) + (0.1*Peak $EEC_{(parent)}$*7.25)	Peak $EEC_{(parent+oxon)}$/ Most sensitive $LC_{50(parent)}$
	Aquatic invertebrates and plants	Total toxic equivalent residues	(% $formed_{(parent)}$*Peak $EEC_{(parent)}$) + (% $formed_{(oxon)}$*Peak $EEC_{(parent)}$) = (0.9*Peak $EEC_{(parent)}$) + (0.1*Peak $EEC_{(parent)}$) = Peak $EEC_{(parent)}$	Peak $EEC_{(parent)}$/ Most sensitive $endpoint_{(parent)}$
Chronic	Fish and aquatic invertebrates	Total toxic equivalent residues	(% $formed_{(parent)}$ *Chronic $EEC_{(parent)}$) + (% $formed_{(oxon)}$ *Chronic $EEC_{(parent)}$) = (0.9*Chronic $EEC_{(parent)}$) + (0.1*Chronic $EEC_{(parent)}$) = Chronic $EEC_{(parent)}$	Chronic $EEC_{(parent)}$/ Most sensitive $endpoint_{(parent)}$

% $formed_{(oxon)}$ = % formed in the aqueous photodegradation study = 0.1
% $formed_{(parent)}$ = 1- (% $formed_{(oxon)}$)
Peak $EEC_{(parent)}$ = Peak EEC for coumaphos from PRZM/EXAMS
Chronic $EEC_{(parent)}$ = 21-day or 60-day EEC for coumaphos from PRZM/EXAMS for aquatic invertebrates and fish, respectively
$TEQ_{(parent)}$ = 1
$TEQ_{(oxon)}$ = 7.25 (from **Table 4-3**)

4.2.1 Monitoring Data

Coumaphos is not included as one of the analytes monitored in the U.S. surface and groundwater under the USGS's National Water Quality Assessment (NAWQA) program. Monitoring data for surface water, groundwater and sediment from the California Department of Pesticide Regulation (CDPR) were searched on September 9, 2013, and all data with analysis for coumaphos were extracted. No detection was reported in surface water and groundwater, and coumaphos was not monitored in sediment (http://www.cdpr.ca.gov/docs/emon/ehap.htm).

4.2.2 Aquatic Exposure Modeling: Runoff

Screening-level surface water exposures for runoff were conducted for coumaphos use on cattle. Modeled application rates represent the application rate estimates based on wash-off fractions from treated cattle (**Table 4-1**). **Table 4-2** provides various application rates used for assessing exposure via runoff. Wash-off fractions for the 24-hour drying time were used in the aquatic exposure assessment because they represent a reasonable time frame after application for a treated cow to be caught in a rainstorm or enter a body of water.

The Pesticide Root Zone Model, (PRZM) and the Exposure Analysis Modeling System (EXAMS) were used in tandem to generate aquatic estimated environmental concentrations (EECs) for parent coumaphos. PRZM (3.12.2 dated May 12, 2005) simulates fate and transport on the agricultural/range land whereas EXAMS (2.98.04.06, dated April 25, 2005) simulates the fate and resulting daily concentrations in the water body. Simulations are carried out with the linkage program shell, PE5V01.pl (dated November 15, 2006), which incorporates the standard non-agricultural scenarios developed by EFED. Simulations are run for multiple (usually 30) years, and the EECs represent peak values that are expected once every ten years based on the thirty years of daily values generated during the simulation. Additional information on these models can be found at: http://www.epa.gov/oppefed1/models/water /index.htm.

Aquatic exposure is estimated for the maximum application pattern to a 10-ha field bordering a 1-ha pond, 2-m deep (20,000 m^3), with no outlet. Exposure estimates generated using this standard pond are intended to represent a wide variety of vulnerable water bodies that occur at the top of watersheds including prairie pot holes, playa lakes, wetlands, vernal pools, man-made and natural ponds, and intermittent and first-order streams. As a group, there are factors that make these water bodies more or less vulnerable than the standard surrogate pond. Static water bodies that have larger ratios of pesticide-treated drainage area to water body volume would be expected to have higher peak EECs than the standard pond. These water bodies will be either smaller in size or have large drainage areas. Smaller water bodies have limited storage capacity and thus may overflow and carry pesticide in the discharge, whereas the standard pond has no discharge. Headwater streams can also have peak concentrations higher than the standard pond, but they likely persist for only short periods of time and are then carried and dissipated downstream. Estimates of coumaphos exposure via runoff from the application of treated manure and CAFOs to agricultural fields are also highly uncertain.

Inputs for PRZM/EXAMS are provided in **Table 4-5**. EECs for surface water (water column) are provided in **Table 4-6**. Pore water concentrations were additionally modeled for the scenario that yielded the most conservative surface water EECs for each runoff exposure pathway (*i.e.*, Range BSS for rangeland; and PA turf for manure and non-regulated small CAFOs) and are provided in **Table 4-7**. PRZM/EXAMS modeling output of EECs for an example scenario (PA Turf) is provided in **Appendix A**.

Table 4-5. PRZM/EXAMS Input Parameters for Coumaphos

Parameter	Input Value	Source	Comment
Use Site	**Pasture**[a] FLTurf BSS Turf[b] PA Turf **Rangeland** BSS Rangeland[2]	---	Assumed coumaphos treated animals grazing on pasture or rangeland
Application Date (DD-MM)	Manure: 15 -10 CAFO Run off: 15- 01 Pasture Runoff: 15-04		Fall application Assumed four stocking/year Spring for grazing
Application Rate		**Table 4-2**	See calculation (**Section 4.1**)
Number of applications per year	1 to 12	**Table 4-2**	Number of application and application frequency based

Parameter	Input Value	Source	Comment
Application interval (days)	10	**Table 4-2**	on either manure or runoff scenarios
Application method	Hand-held spray or dip vat method	Label directions	---
CAM	1	---	Surface application of manure
	1	--	Assumed for wash-off from animal hide
	4	--	Incorporation of manure to a depth of 8 inches (20.3 cm)[c]
Hydrolysis ($t_{1/2}$)	0	MRID 46902201	Stable
Spray drift fraction	Not applicable	---	---
Aerobic soil metabolism ($t_{1/2}$)	0 day (stable)	MRID 40518701	
Aerobic aquatic metabolism ($t_{1/2}$)	0 day (stable)	No Data	Input Parameter Guidance (USEPA, 2009)
Anaerobic aquatic metabolism ($t_{1/2}$)	0 day	No Data	Input Parameter Guidance (USEPA, 2009)
Aquatic photolysis ($t_{1/2}$)	1.38 days	MRID 42764101 MRID 43103901	---
Vapor pressure	1. 0E-07 (mmHg)	US EPA, 2007	---
Solubility in water (pH 7, 20 °C)	20 mg/L		
Molecular weight	362.78 g/mole		
Henry's Law constant (20 °C)	2.62E-09 atm.m^3 /mol		Estimated[d]
Partition coefficient K_{oc}	5904 mL/g	MRID 46808411	Represents average K_{oc} for 4 soils

[a] Turf scenarios were used as surrogate scenarios for pasture land

[b] Major use of coumaphos is in dip vats by USDA (APHIS) on the Texas-Mexico border for cattle coming into the United States from Mexico in the tick quarantine zone in Texas. Since no PRZM/EXAMS standard scenario is available for Texas, BSS Turf and BSS Rangeland were used as surrogate scenarios for coumaphos

[c] http://ohioline.osu.edu/agf-fact/0208.html

[d] http://www.epa.gov/oppefed1/models/water/input_parameter_guidance.htm

Table 4-6. Estimated Environmental Concentrations (EECs) of Coumaphos in Surface Water from Runoff for Various Application Scenarios

PRZM/ EXAMS Scenario	Sources of a.i. from Application Scenario	Wash-Off Fraction	Peak $EEC_{(parent)}$ (µg/L) (Coumaphos)	Peak $EEC_{(parent+oxon)}$* (µg/L) (Coumaphos + Coumaphoxon)		Chronic $EEC_{(parent+oxon)}$* (µg/L) (Coumaphos + Coumaphoxon)	
				Fish	Aquatic Inverts and Plants	21-day (Aquatic Inverts)	60-day (Fish)
Texas: Spray Application (42% flowable concentrate)							
BSSTurf[a]	Runoff from CAFO manure applied to land	No incorporation of manure into soil					
		0.02	0.05	0.08	0.05	0.03	0.03
		Incorporation of manure into soil within a day					
		0.02	0.0031	0.01	0.0031	0.0021	0.0018
	Runoff from non-regulated small CAFO	0.02	0.25	0.41	0.25	0.21	0.18
RangeBSS[b]	Runoff from rangeland	0.02	0.005	0.01	0.005	0.004	0.004
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)							
FL Turf	Runoff from CAFO manure applied to land	No incorporation of manure into soil					
		0.027	0.02	0.03	0.02	0.02	0.01
	Runoff from non-regulated small CAFO	0.027	0.14	0.23	0.14	0.10	0.09
	Runoff from rangeland[b,c]	0.027	0.0006	0.0010	0.0006	0.0005	0.0004
PA Turf	Runoff from CAFO manure applied to land	No incorporation of manure into soil					
		0.027	0.04	0.07	0.04	0.03	0.03
		Incorporation of manure into soil within a day					
		0.027	0.0022	0.0036	0.0022	0.0018	0.0017
	Runoff from non-regulated small CAFO	0.027	0.29	0.47	0.29	0.23	0.21
	Runoff from rangeland[b,c]	0.027	0.0013	0.0021	0.0013	0.0011	0.0010

AU = animal unit
* Used to calculate RQs
[a] Used as surrogate scenario for pasture land
[b] Cattles grazing on rangeland
[c] In absence of rangeland scenario in FL and PA, turf scenarios from FL and PA were used as surrogate scenarios for rangeland.

Table 4-7. Estimated Environmental Concentrations (EECs) of Coumaphos in Pore Water from Runoff for Selected Application Scenarios

PRZM/ EXAMS Scenario	Sources of a.i. from Application Scenario	Wash-Off Fraction	Peak $EEC_{(parent+oxon)}$ (µg/L) (Coumaphos + Coumaphoxon)	21-day $EEC_{(parent+oxon)}$ (µg/L) (Coumaphos + Coumaphoxon)	Ratio of Surface Water $EEC_{(parent+oxon)}$[a]: Pore Water $EEC_{(parent+oxon)}$	
					Peak	21-day
Texas: Spray Application (42% flowable concentrate)						
BSSTurf	Runoff from non-regulated small CAFO	0.02	0.17	0.17	1.5	1.2
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)						
PA Turf	Runoff from non-regulated small CAFO	0.027	0.19	0.19	1.5	1.2

[a] Peak $EEC_{(parent+oxon)}$ for aquatic invertebrates from **Table 4-6**

4.2.3 Wash-off from the Skin of Treated Livestock That Enter Bodies of Water

For aquatic exposure from wash-off from the skin of treated livestock that enter bodies of water:

- Surface water EECs were calculated as "EEC per treated cow wading into a body of water" (*i.e.*, EEC/cow; **Table 4-8**) using the maximum single application rates of 0.027 and 0.01 lb a.i./animal for Texas and the rest of the U.S., respectively. The equation provided in **Table 4-9** was used to generate surface water EECs for coumaphos which were then adjusted using the TEQ and TTR approaches to yield total EECs (coumaphos + coumaphoxon).
- Pore water EECs were calculated as EEC/cow (**Table 4-10**) using surface water EECs (**Table 4-6**) and the ratio of surface water $EEC_{(parent+oxon)}$: pore water $EEC_{(parent+oxon)}$ for runoff (**Table 4-7**).

Table 4-8. Surface Water Estimated Environmental Concentrations (EECs) from Wash-Off from the Skin of Treated Livestock That Enter Bodies of Water

Maximum Application Rate			Wash-Off Fraction[c]	Peak EEC (parent) /cow[d] (µg/L) (Coumaphos)	Peak $EEC_{(parent+oxon)}$/cow[d] (µg/L) (Coumaphos + Coumaphoxon)		Chronic $EEC_{(parent+oxon)}$/cow[d] (µg/L) (Coumaphos + Coumaphoxon)
Type	(lb a.i./ animal)[a]	(mg a.i./ ft^2 cow hide)[b]			Fish	Aquatic Invertebrates and Plants	
Texas: Dip Vat Application (42% flowable concentrate)							
Single	0.027	272	0.02	0.008	0.013	0.008	0.008
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)							
Single	0.01	101	0.027	0.004	0.007	0.004	0.004

[a] **Table 2-1**
[b] See **Table 4-12** for calculation
[c] **Table 4-1**
[d] EEC per treated cow wading into a body of water that is 1 acre, 6 feet deep; calculated using equation in **Table 4-4**

Table 4-9. Equation for Calculating Estimated Environmental Concentration (EEC) per Treated Cow Wading into a 1 Acre, 6 foot Deep Body of Water[a] (*i.e.*, EEC/Cow) [12]

EEC/cow = surface area of cow in square feet[a] x µg coumaphos per square feet of hide[b] x fraction of cow surface submerged in a body of water containing non-target organisms (*i.e.*, 0.25)[c] x wash-off fraction x 2.205 x 10^{-9} lb/µg x 61 µg/L concentration in pond per lb loading

[a] The surface area of a 1000-2000 lb cow is about 45 sq ft, based on communication from Jerry Breiter of the U.S. Hide, Skin and Leather Association (USHSLA) (USEPA, 1996).
[b] see **Table 4-12** for calculation
[c] A cow will generally enter water up to the hair break line, which is a clearly visible line on the sides of the cow, where the types of hair change visibly. According to the USHSLA, this means that about 25% of the skin surface is submerged (USEPA, 1996).

[12] For details on calculation of EEC, see USEPA, 1996.

Table 4-10. Pore Water Estimated Environmental Concentrations (EECs) from Wash-Off from the Skin of Treated Livestock That Enter Bodies of Water

Maximum Application Rate			Wash-Off Fraction[c]	Peak EEC$_{(parent+oxon)}$/cow[d,e] (µg/L) (Coumaphos + Coumaphoxon)	Chronic EEC$_{(parent+oxon)}$/cow[d,e] (µg/L) (Coumaphos + Coumaphoxon)
Type	(lb a.i./ animal)[a]	(mg a.i./ ft^2 cow hide)[b]		Benthic Invertebrates	
Texas: Dip Vat Application (42% flowable concentrate)					
Single	0.027	272	0.02	0.005	0.007
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)					
Single	0.01	101	0.027	0.003	0.003

[a] **Table 2-1**
[b] See **Table 4-12** for calculation
[c] **Table 4-1**
[d] EEC per treated cow wading into a body of water that is 1 acre, 6 feet deep; calculated using equation in **Table 4-4**
[e] = surface water EEC from **Table 4-8** / ratio of surface water EEC$_{(parent+oxon)}$: pore water EEC$_{(parent+oxon)}$ from **Table 4-7**

4.3 Terrestrial Exposure

4.3.1 Birds and Mammals

Birds may be exposed to coumaphos via contact with/ingestion of hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas. Additionally, birds and mammals may be exposed to coumaphos via ingestion of coumaphos-contaminated bird carcasses, ingestion of food items on land receiving manure from CAFOs, and ingestion of contaminated fish.

4.3.1.1 Contact with/Ingestion of Hair and Skin Debris from Treated Cattle and/or Contaminated Soil and Feed in and around Treatment Areas (Primary Exposure)

Evidence for avian exposure via contact with/ingestion of hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas has been confirmed by a pilot field study submitted to the Agency (MRID 42512604). Eight cattle in one pen were sprayed with coumaphos (2 lb a.i. in 50 gal water) until each individual was thoroughly soaked. After treatment, coumaphos residues were detected in soil samples, cow feces, cow hair samples, and stomach contents of cowbirds (see **Table 4-11** for residues in soil, hair, and feces). Brain cholinesterase activity was inhibited 2-59% in 13 of 19 cowbirds examined. Thirty-four bird species were recorded within 200 m of the treatment site, with six species observed on the ground in the pen. Based on several counts, 290 birds were estimated to frequent the 3.7-hectare pen. The results from treating only 8 cows in one pen were too limited in scope to draw any major conclusions. However, the study did indicate that a variety of birds are likely to be present at treatment sites and that they may be exposed to coumaphos residues from soil from cowpens, bovine feces, and bovine hair. The study also included information regarding bird use of feedlots and pastures, and species likely to be exposed, ranked in order of potential exposure in feedlots. Due to its close association with cattle, the black-billed magpie was listed as the species most likely to be exposed.

Table 4-11. Coumaphos Residues (Mean ± SD ppm) for Pilot Field Study (MRID 42512604)

Source	Pre-Treatment	Hours Post-Treatment		
		1	24	72
Soil from cowpens	50.7 ± 21.3 (n = 8)	344 ± 251 (n = 16)	114 ± 137 (n = 8)	142 ± 153 (n = 8)
Bovine hair	0.164 ± 0.126 (n = 8)	1,228 ± 158 (n = 8)	853 ± 250 (n = 8)	370 ± 98 (n = 8)
Bovine feces*	0.0962 ± 0.1847 (n = 8)	0.0791 ± 0.1346 (n = 7)	0.0088 ± 0.0080 (n = 8)	≤ 0.0015 ± 0 (n = 8)

* collected via rectal palpation

Mass of coumaphos per square foot of cow hide was used a conservative dose-based estimated exposure concentration (EEC) for characterizing exposure of birds to coumaphos via contact with/ingestion of hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas (**Table 4-12**). Dose-based EECs were calculated for the maximum single application rates based on information from labels (*i.e.*, Texas, dip vat application: 0.027 lb a.i./animal; rest of U.S., back rubber application: 0.01 lb a.i./animal) and information from the U.S. Hide, Skin and Leather Association (USHSLA).

Mean residues of coumaphos detected in bovine hair (a surrogate for potential contaminated food items) 1, 24, and 72 hours post-treatment as reported in the pilot field study (MRID 42512604) – 1228, 853, and 370 mg a.i./kg-diet, respectively – were used as dietary-based EECs for characterizing exposure of birds to coumaphos via contact with/ingestion of hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas.

Table 4-12. Dose-Based Estimated Environmental Concentrations (EECs) for Treated Cow Hide

Maximum Application Rate			Cow Hide Surface Area[a] (ft^2)	Dose-Based EEC (mg a.i./ft^2 cow hide)
Type	(lb a.i./animal)	(mg a.i./animal)		
Texas: Dip Vat Application (42% flowable concentrate)				
Single	0.027	12,247	45	272
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)				
Single	0.01	4,536	45	101

[a] The surface area of a 1000-2000 lb cow is about 45 sq ft, based on communication from Jerry Breiter of the U.S. Hide, Skin and Leather Association (USHSLA) (USEPA, 1996).

4.3.1.2 Ingestion of Coumaphos-Contaminated Bird Carcasses (Secondary Exposure)

Dose- and dietary-based EECs for secondary exposure of birds and mammals via ingestion of coumaphos-contaminated bird carcasses were calculated. Both types of EECs required the estimation of the concentration of coumaphos in a bird carcass since no empirical residue data are available.

The concentration of coumaphos in a bird carcass (mg a.i./g-bw) was assumed to be equivalent to potential coumaphos intake on a single day (mg a.i./g-bw/day) by the species most likely to be exposed to coumaphos according to the pilot field study (MRID 42512604), the black-billed magpie. In turn, the potential coumaphos intake on a single day by a black-billed magpie was assumed to represent the maximum concentration in the carcass (*i.e.*, there is no longer term accumulation of residues in the tissue beyond what would be expected from intake on a single day). The concentrations of coumaphos in food items –1228, 853, and 370 mg a.i./kg-diet = 1.228, 0.853, and 0.370 mg a.i./g-diet – were assumed to be equivalent to the mean residues of coumaphos detected in bovine hair (a surrogate for potential contaminated food items) 1, 24, and 72 hours post-treatment, respectively, as reported in the pilot field study (MRID 42512604). Using the formulas and additional assumptions provided in **Table 4-13**, the concentrations of coumaphos in a black-billed magpie carcass were estimated to range from 0.039 to 0.129 mg a.i./g-bw.

Dose-based EECs for secondary exposure of birds and mammals via ingestion of coumaphos-contaminated bird carcasses were assumed to be equivalent to the potential coumaphos intake on a single day (*i.e.*, mg a.i./g-bw/day) by a red-tailed hawk and a red fox, respectively. These two predators/scavengers were chosen because they are representative of a mammal and bird, respectively, that could be exposed secondarily to coumaphos via ingestion of contaminated bird carcasses. Assumptions and formulas used to calculate potential daily coumaphos intake by birds and mammals via secondary exposure are provided in **Table 4-13**. Dosed-based EECs as coumaphos intake for this route of exposure were estimated to range from 4.16×10^{-6} to 1.38×10^{-5} mg a.i./g-bw/day and 1.17×10^{-5} to 3.87×10^{-5} mg a.i./g-bw/day for the red fox and red-tailed hawk, respectively. Assuming no degradation of coumaphos in the contaminated bird carcass prior to consumption by the predator/scavenger (*e.g.*, red-tailed hawk and red fox, respectively), dietary-based EECs for secondary exposure of birds and mammals via ingestion of coumaphos-contaminated bird carcasses were estimated to range from 0.039 to 0.129 mg a.i./g-diet, the range of estimated concentrations of coumaphos in a bird carcass.

Table 4-13. Assumptions and Formulas Used to Calculate Coumaphos Intake (CI) via (a) Primary and (b) Secondary Exposure

a) Primary exposure[a]

Assumptions

- The black-billed magpie, the species most likely to be exposed to coumaphos according to the pilot field study (MRID 42512604), is the consuming individual.
- The weight of a black-billed magpie (*Pica pica*) is 186 g (Dunning, 1984).
- The concentrations of coumaphos in food items –1228, 853, and 370 mg a.i./kg-diet = 1.228, 0.853, and 0.370 mg a.i./g-diet – are the mean residues of coumaphos detected in bovine hair (a surrogate for potential contaminated food items) 1, 24, and 72 hours post-treatment, respectively, as reported in the pilot field study (MRID 42512604).
- Bovine hair is 100% dry material. Thus, food dry weight is equivalent to food wet weight.
- The black-billed magpie consumes 100% of its diet as food items contaminated with coumaphos at a concentration of 1.228, 0.853, or 0.370 mg a.i./g-diet.

Formulas

FI[b] (g dry-wt/day)$_{(\text{black-billed magpie})}$ = 0.648 * Wt (g)$^{0.651}$ = 0.648 * (186)$^{0.651}$ = 19.5 g dry-wt/day

FI (g wet-wt/day)$_{(\text{black-billed magpie})}$ = FI (g dry-wt/day)$_{(\text{black-billed magpie})}$ = 19.5 g wet-wt/day

CI (mg/g-bw/day)$_{(\text{black-billed magpie})}$ = <u>FI (g wet-wt/day)$_{(\text{black-billed magpie})}$ * Coumaphos dietary concentration (mg a.i./g-diet)</u>

Wt(g)

= (19.5 * [0.370, 0.853, or 1.228]) / 186

= 0.039, 0.089, or 0.129 mg a.i./g-bw/day

Where:
FI = food intake
CI = coumaphos intake
Wt = weight
Coumaphos dietary concentration (mg/g-diet) = 1.450 mg a.i./g-diet[d]

b) Secondary exposure[e]

Assumptions

For mammals:

- The red fox (*Vulpes vulpes*) is the consuming individual.
- The weight of a red fox is 4.5 kg = 4500 g (USEPA, 1993b)
- The daily intake rate of a red fox is 0.16 g dry-wt/g-bw (USEPA, 1993b).

For birds:

- The red-tailed hawk (*Buteo* species) is the consuming individual.
- The weight of a red-tailed hawk is 1.1 kg = 1100 g (USEPA, 1993b)
- The daily intake rate of red-tailed hawk is 0.11 g dry-wt/g-bw (USEPA, 1993b).

For birds and mammals:

- A bird carcass is 67% water (USEPA, 1993b).
- A red fox/red-tailed hawk consumes 100% of its diet as bird carcasses contaminated with coumaphos at a concentration of 0.129, 0.089, or 0.039 mg a.i./g-bw/day (calculated in (a)).
- There is no degradation of coumaphos in a bird carcass prior to consumption by a red fox/red-tailed hawk.

Formulas

FI (g wet-wt/day) = FI (g dry-wt/day) / 0.33

$FI\ (g\ wet\text{-}wt/day)_{(red\ fox)} = 0.16/0.33 = 0.48$ g wet-wt/day
$FI\ (g\ wet\text{-}wt/day)_{(red\text{-}tailed\ hawk)} = 0.11/0.33 = 0.33$ g wet-wt/day

$$CI\ (mg/g\text{-}bw/day) = \frac{FI\ (g\ wet\text{-}wt/day) * \text{Coumaphos dietary concentration}\ (mg\ a.i./g\text{-}diet)}{Wt(g)}$$

$CI\ (mg/g\text{-}bw/day)_{(red\ fox)} = (0.48 * [0.039, 0.089, \text{or } 0.129])/4500$
$= \mathbf{4.16 \times 10^{-6}, 9.49 \times 10^{-6}, \text{or } 1.38 \times 10^{-5}}$ **mg a.i./g-bw/day**
$CI\ (mg/g\text{-}bw/day)_{(red\text{-}tailed\ hawk)} = (0.33 * [0.039, 0.089, \text{or } 0.129])/1100$
$= \mathbf{1.17 \times 10^{-5}, 2.67 \times 10^{-5}, \text{or } 3.87 \times 10^{-5}}$ **mg a.i./g-bw/day**

Where:
FI = food intake
CI = coumaphos intake
Wt = weight
Coumaphos dietary concentration (mg/g-diet) = 0.152 mg a.i./g-diet

[a] ingestion of contaminated food items
[b] equation for all birds (USEPA, 1993b, pg. 3-4)
[c] for females (Dunning, 1984)
[d] highest coumaphos residue detected in potential contaminated food items (*e.g.*, soil, hair, feces) as reported in the pilot field study (MRID 42512604)
[e] ingestion of coumaphos-contaminated bird carcasses

4.3.1.3 Ingestion of Food items on Land Receiving Manure from CAFOs

EECs for ingestion of food items on land receiving manure from CAFOs were calculated using the T-REX model[13] (v1.5.2; June 6, 2013), a Tier 1 model for screening-level assessments of pesticides. T-REX estimates terrestrial animal exposure values resulting from possible dietary ingestion of pesticide residues present on non-food and food items. The T-REX model determines (1) EECs for birds and mammals and (2) risk to birds and mammals via calculation of risk quotients (RQs). In all screening-level assessments, the organisms are assumed to consume 100% of their diet as one food type. EECs in terms of LD_{50}/ft^2 and associated RQs for broadcast granular applications were deemed to be most applicable to exposure via ingestion of food items on land receiving manure from CAFOs.

Input parameters for broadcast granular applications include a maximum application rate, number of applications, application interval, and definitive acute LD_{50} toxicity endpoints for birds and mammals (**Table 4-14**).

[13] http://www.epa.gov/oppefed1/models/terrestrial/index.htm

Table 4-14. Input Parameters for T-REX Modeling of Broadcast Granular Applications (Surrogate for CAFO Manure Applied to Land)

Source of Exposure		Input Parameters		
		Maximum Single Application Rate[a] (lb a.i./A)	Maximum Annual Number of Applications[a]	Other Parameters
Texas: Spray Application (42% flowable concentrate)				Avian LD_{50} = 2.4 mg/kg-bw (bobwhite quail; MRID 00112843) Mammalian LD_{50} = 17 mg/kg-bw (rat; MRID 00110597)
CAFO manure applied to land	No incorporation into soil	0.015	1	
	Incorporation into soil within a day	0.009	1	
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)				
CAFO manure applied to land	No incorporation into soil	0.0092	1	
	Incorporation into soil within a day	0.0051	1	

[a] **Table 4-2**

Results of T-REX modeling of coumaphos EECs in terms of LD_{50}/ft^2 from application of CAFO manure to land are provided in **Tables 4-15**.

Table 4-15. Avian and Mammalian Estimated Exposure Concentrations (EECs) for Application of CAFO Manure to Land

Source of Exposure		EEC: LD_{50}/ft^2 (mg a.i./ft^2)
Texas: Spray Application (42% flowable concentrate)		
CAFO manure applied to land	No incorporation into soil	0.16
	Incorporation into soil within a day	0.09
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)		
CAFO manure applied to land	No incorporation into soil	0.10
	Incorporation into soil within a day	0.05

4.3.1.4 Ingestion of Contaminated Fish

EECs for ingestion of contaminated fish were calculated using KABAM (KOW (based) Aquatic BioAccumulation Model; v. 1.0; April 9, 2009). KABAM estimates potential bioaccumulation of hydrophobic organic pesticides in freshwater aquatic food webs and subsequent risks to mammals and birds via consumption of contaminated fish. KABAM is composed of two parts: 1) a bioaccumulation model estimating pesticide concentrations in aquatic organisms and 2) a risk component translating exposure and toxicological effects of a pesticide into risk estimates for mammals and birds consuming contaminated fish. The bioaccumulation portion of KABAM is based on an aquatic food web bioaccumulation model published by Arnot and Gobas (2004). The bioaccumulation portion of KABAM relies on a pesticide's octanol-water partition coefficient (KOW) to estimate uptake and elimination constants through respiration and diet of aquatic organisms in different trophic levels. Pesticide tissue concentrations in aquatic organisms are calculated for different trophic levels of a food web through diet and respiration. In the risk component of KABAM, pesticide concentrations in aquatic organisms are used to estimate dose- and dietary-based exposures and associated risk quotients for mammals and birds consuming aquatic organisms.

Input parameters for KABAM include Log Kow (=4.3), Koc (=5904 L/kg oc), a pore water EEC, a water column EEC, rate constants for various tropic levels (*e.g.*, default metabolism rate constant, Km = 0), and definitive toxicity endpoints for birds and mammals (see **Appendix B, Table B-1**). For runoff, EECs for the scenarios that yielded the highest values (*i.e.*, Texas: BSSTurf, runoff from unregulated small CAFO; rest of the U.S.: PA Turf, runoff from unregulated small CAFO) were used. For wash-off from treated livestock that enter bodies of water, this analysis was conducted using the EEC for wash-off fraction 0.02 (Texas) or 0.027 (rest of the U.S.) and 100 cows entering a body of water. The upper limit of 100 cows was selected based on literature indicating that a 6 foot deep, 1 acre farm pond would be suitable for watering 100 cows (Bray, 2013).

Results indicated RQ exceedances so model inputs were refined to more accurately reflect the fast elimination of coumaphos in fish as documented in the BCF study (MRIDs 00115168 and 00150619). Specifically, the fish BCF study shows that 95% of accumulated coumaphos is depurated within 24 hours of fish being place in clean water. Raw data from the BCF study was used to calculate a fish Km of 0.936/day. This Km was used as an input for small, medium, and large fish, and KABAM was allowed to calculate the remaining rate constants (*e.g.*, uptake an elimination constants through diet and respiration) for fish.

4.3.2 Terrestrial (Upland and Semi-Aquatic) Plants

Terrestrial (upland and semi-aquatic) plants could be exposed to coumaphos via uptake from CAFO manure applied to land and uptake from soil receiving runoff from land to which manure from CAFOs has been applied.

EECs for exposure via uptake from soil receiving runoff from land to which manure from CAFOs has been applied were calculated using TerrPlant (v1.2.2; October 29, 2009)[14]. TerrPlant, a Tier 1 model for screening-level assessments of pesticides, is used to estimate exposure to terrestrial plants from single pesticide applications; the model does not consider exposures to plants from multiple pesticide applications. TerrPlant determines (1) EECs in runoff and in spray drift and (2) risk to non-listed and listed species of monocots and dicots inhabiting dry (upland) and semi-aquatic areas via calculation of risk quotients (RQs).

Input parameters for TerrPlant include maximum single application rate, incorporation depth (1 inch; default), runoff fraction (2% based on the water solubility of coumaphos – 20 mg/L), spray drift fraction, and definitive toxicity endpoints from seedling emergence and vegetative vigor studies (**Table 4-16**). Given that exposure via this pathway includes runoff only, a spray drift fraction of 0% was assumed. EECs used to evaluate potential risk to terrestrial plants for runoff from land to which manure from CAFOs has been applied are provided under the column titled "Runoff EECs" in **Table 4-17**.

[14] http://www.epa.gov/oppefed1/models/terrestrial/index.htm

EECs for the exposure via uptake from CAFO manure applied to land were assumed to be equivalent to application rates calculated for unincorporated manure in **Table 4-2** and are provided under the column titled "Direct Application EEC" in **Table 4-17**.

Table 4-16. Input Parameters for TerrPlant Modeling

Source of Exposure		Input Parameters: Application Rate (lb a.i./A)	Input Parameters: Other Parameters
Texas: Spray Application (42% flowable concentrate)			Incorporation depth = ≤ 1 inch Runoff fraction = 2% Spray drift fraction = 0% SE endpoints: None[a] VV endpoints: None[a]
Runoff from land to which CAFO manure has been applied	No incorporation into soil	0.015	
	Incorporation into soil within a day	0.009	
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)			
Runoff from land to which CAFO manure has been applied	No incorporation into soil	0.0092	
	Incorporation into soil within a day	0.0051	

SE = seedling emergence; VV = vegetative vigor
[a] The are no toxicity data that are specific to coumaphos and suitable for calculation of RQs.

Table 4-17. Terrestrial (Upland and Semi-aquatic) Plant Estimated Exposure Concentrations (EECs) for CAFO Manure Applied to Land

Source of Exposure		Application Rate[a]	Direct Application EEC[c] (lb a.i./A)	Runoff EEC[b] (lb a.i./A)	
			All Areas	Dry (Upland) Areas	Semi-Aquatic Areas
Texas: Spray Application (42% flowable concentrate)					
CAFO manure applied to land	No incorporation into soil	0.015	0.015	0.0003	0.003
	Incorporation into soil within a day	0.009		0.00018	0.0018
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)					
CAFO manure applied to land	No incorporation into soil	0.0092	0.0092	0.000184	0.00184
	Incorporation into soil within a day	0.0051		0.000102	0.00102

[a] From **Table 4-2**
[b] From TerrPlant
[c] assumed to be equivalent to application rates calculated for unincorporated manure

4.3.3 Honey Bees (In-Hive Use)

Honey bees may be exposed to coumaphos via impregnated strips placed in hives to control varroa mites and hive beetles. Data on coumaphos residues (mg/kg) detected in bees, wax, and queen cells from hives with coumaphos-impregnated strips are available from open literature study E066848 as identified via ECOTOX[15] (**Table 4-18**). The former study (E066848), which was classified as "qualitative" for use in the assessment (see **Section 5.2.3** for rationale), described two separate experiments with coumaphos. In one experiment, colonies received

[15] http://cfpub.epa.gov/ecotox/

plastic strips containing no coumaphos (control), a low dose of coumaphos (*i.e.*, ¼ coumaphos-impregnated strip per frame in the starter colonies and ¼ strip per mating nuc), or a high dose of coumaphos (*i.e.*, ½ coumaphos-impregnated strip per frame in starter colonies and ½ strip per mating nuc). In the second experiment, colonies received hanging plastic strips containing no coumaphos (control), 3 coumaphos-impregnated strips adjacent to cell frames but not touching the cell frames, 3 coumaphos-impregnated strips adjacent to cell frames, or 3 coumaphos-impregnated strips cut up and attached directly to each cell bar (½ strip per bar). Concentrations in bees, wax and queen cells of hives treated with coumaphos-impregnated strips ranged from 0.83-23.26, 12.69-120, and 8.11-237 mg/kg, respectively (**Table 4-18**).

Table 4-18. Coumaphos Residues in Samples of Bees, Wax, and Queen Cells from Hives Treated with Coumaphos-Impregnated Strips[a]

Sample type	Treatment	Pre-Treatment Concentration (mg/kg)	Post-Treatment Concentration (mg/kg)
Experiment #1			
Bee	Control[b]	< Level of detection	0.13
	Low[c]	< Level of detection	0.83
	High[d]	1.54	6.47
Wax	Control[b]	< Level of detection	0.17
	Low[c]	0.30	49.7
	High[d]	0.36	120
Queen cells	Control[b]	Not applicable	< Level of detection
	Low[c]		181
	High[d]		237
Experiment #2			
Bee	Control[b]	Did not measure	0.57
	2 strips attached[e]		3.36
	2 strips adjacent[f]		23.26
	2 strips not touching[g]		9.95
Wax	Control[b]	Did not measure	<LOD
	2 strips attached[e]		12.69
	2 strips adjacent[f]		22.22
	2 strips not touching[g]		12.85
Queen cells	Control[b]	Did not measure	NA
	2 strips attached[e]		91.93
	2 strips adjacent[f]		28.17
	2 strips not touching[g]		8.11

[a] Source of data: Open literature study E066848 as identified via ECOTOX
[b] plastic strips containing no coumaphos
[c] ¼ coumaphos-impregnated strip per frame in the starter colonies and ¼ strip per mating nuc
[d] ½ coumaphos-impregnated strip per frame in starter colonies and ½ strip per mating nuc
[e] 3 coumaphos-impregnated strips cut up and attached directly to each cell bar (½ strip per bar)
[f] 3 coumaphos-impregnated strips adjacent to cell frames
[g] 3 coumaphos-impregnated strips adjacent to cell frames but not touching the cell frames

In addition, data for coumaphos residues in comb wax, stored pollen, and live bees as well as coumaphos oxon residues in wax from a broad survey of pesticide residues sampled from commercial bee hives in North America are available (MRID 49497801; **Table 4-22**). Concentrations of coumaphos in wax, pollen, and bees ranged from 0.001-91.9, 0.001-5.83, and 0.001-0.762 mg/kg, respectively, and concentration of coumaphos in wax ranged from 0.0013-1.3 mg/kg.

Table 4-22: Summary of Coumaphos Detections in Samples from North American Honey Bee Colonies[a]

Sample Type	Detects (%)	Number of Samples Analyzed	Detections (mg/kg) High	Low	Median	90% tile	95% tile	Mean	SEM	LOD
Coumaphos										
Wax	254 (98.1)	259	91.9000	0.0010	1.2400	6.8750	11.3400	3.30040	0.49980	0.0010
Pollen	263 (75.1)	350	5.8280	0.0010	0.0131	0.5184	0.8920	0.1804	0.0330	0.0010
Bees	84 (60.0)	140	0.7620	0.0010	0.0080	0.1187	0.1562	0.0504	0.0135	0.0010
Coumaphos oxon										
Wax	187 (98.9)	208	1.3000	0.0013	0.0561	0.1842	0.2698	0.1027	0.0125	0.0050

LOD = level of detection; SEM = standard error of the mean
[a] Source of data: MRID 49497801

5 Effects Characterization

Data are obtained from registrant-submitted studies or from open literature studies identified by ECOTOX[16] to characterize the effects of coumaphos to non-target organisms. Additional effects characterization is provided by reviews of reported incidents involving use of coumaphos.

A data call-in (DCI) was issued for two toxicity studies after the 2008 problem formulation:

- 850.4400 – Aquatic Plant Toxicity Test
- 850.5400 – Algal Toxicity

The registrant subsequently submitted a Tier II aquatic vascular plant study with *Lemna gibba* (MRID 48322801) and a Tier II aquatic non-vascular plant study with the green alga *Pseudokirchneriella subcapitata* (MRID 48322802). The study with *L. gibba* yielded an EC_{50} of 166 µg a.i./L and a NOAEC of 166 µg a.i./L and was classified as "supplemental" due to a guideline deviation (*i.e.*, a the number of plants per replicate was lower than recommended); the study with *P. subcapitata* was classified as "invalid" because the solvent had a stimulatory effect that could have masked the true effects of coumaphos. An additional aquatic non-vascular plant study for coumaphos was not requested based on an analysis presented in an EFED memo indicating that aquatic non-vascular plant toxicity data for a surrogate organophosphate insecticide could be used to characterize the toxicity of coumaphos to aquatic non-vascular plants (DP 406398, October 31, 2012; see **Section 5.1.6** for additional details).

There are several open literature studies on the effects of coumaphos to bees that are used in this assessment (see **Table 5-6**). Other open literature studies also referenced coumaphos, but these are not included in this assessment because: the reported toxicity endpoints are less sensitive than those from registrant-submitted studies; the information is not appropriate for inclusion for a variety of reasons including the reported endpoint is not comparable to a guideline endpoint; or the reported endpoint is not convertible to units used in risk assessment models. Coumaphos studies that are found in the open literature and passed the initial screen but were not used in the assessment are provided in **Appendix C**.

5.1 Effects to Aquatic Organisms

Summaries of data used to characterize the effects of coumaphos to aquatic organisms are provided in **Table 5-1**. The most sensitive definitive toxicity endpoints used in RQ calculations are bolded.

5.1.1 Freshwater Fish

Based on studies with bluegill sunfish, lake trout, walleye, channel catfish, cutthroat trout, rainbow trout, and largemouth bass, coumaphos is moderately to highly toxic to freshwater fish on an acute basis.

[16] http://cfpub.epa.gov/ecotox/

In studies with bluegill sunfish, lake trout, walleye, channel catfish, cutthroat trout, rainbow trout, and largemouth bass (MRID 40098001), LC_{50}'s ranged 340 to 1100 µg a.i./L. No sublethal effects were specified in these studies.

In a second study with bluegill sunfish (MRID 00112840), the LC_{50} was 5000 µg a.i./L, and the sublethal effect of erratic swimming was noted. In a second study with rainbow trout (MRID 00112840), the LC_{50} was 5900 µg a.i./L, and sublethal effects including erratic swimming, loss of reflex, and discoloration were observed.

In an early life-stage study with rainbow trout (MRID 43066301), the NOAEC of 11.7 µg a.i./L was based on the most sensitive endpoints of length and weight (day 62). However, day 36 post-hatch survival and length were also affected at $\geq$ 96.1 µg a.i./L, and day 62 post-hatch survival was affected at $\geq$ 48.4 µg a.i./L.

Since the freshwater fish chronic toxicity endpoint of 11.7 µg/L (rainbow trout; MRID 43066301) was not generated using the most acutely sensitive freshwater fish (*i.e.*, bluegill sunfish), a chronic toxicity endpoint for bluegill sunfish of 4.4 µg/L was calculated using the acute toxicity endpoint for bluegill sunfish and an acute to chronic ratio (ACR) for rainbow trout (see **Table 5-1** for calculation).

5.1.2 Estuarine/Marine Fish

Based on an acute toxicity study with sheepshead minnow, coumaphos is highly toxic to estuarine/marine fish. The LD_{50} for this study (MRID 40228401) was 280 µg a.i./L; sublethal effects were not specified.

No data are available for the chronic toxicity of coumaphos to estuarine/marine fish. Therefore, a chronic toxicity endpoint for estuarine/marine fish of 3.6 µg/L was calculated using the acute toxicity endpoint for sheepshead minnow and an ACR for freshwater fish (*i.e.*, rainbow trout) (see **Table 5-1** for calculation).

Table 5-1. Endpoints Used to Characterize the Effects of Coumaphos to Aquatic Organisms

Assessment Endpoint	Measurement Endpoint	% a.i.	Species	Toxicity Endpoints[a,b] (Effects) & Acute Toxicity Classification (if applicable)	Source & Classification
Survival, growth, and reproduction of freshwater fish (surrogate for aquatic-phase amphibians)	Most sensitive freshwater fish acute LC_{50}	95	Bluegill sunfish (*Lepomis macrochirus*)	96-hr LC_{50} = **340** µg a.i./L Highly toxic	MRID 40098001 Mayer and Ellersieck (1996)
		95	Lake trout (*Salvelinus namaycush*)	96-hr LC_{50} (95% C.I.) = 593 (416-846) µg a.i./L Highly toxic	MRID 40098001 Mayer and Ellersieck (1996)
		95	Walleye (*Stizostedion vitreum vitreum*)	96-hr LC_{50} (95% C.I.) = 780 (645-943) µg a.i./L Highly toxic	MRID 40098001 Mayer and Ellersieck (1996)
		95	Channel catfish (*Ictalurus punctatus*)	96-hr LC_{50} (95% C.I.) = 840 (620-1140) µg a.i./L Highly toxic	MRID 40098001 Mayer and Ellersieck (1996)
		95	Cutthroat trout (*Salmo clarki*)	96-hr LC_{50} (95% C.I.) = 862 (645-1150) µg a.i./L Highly toxic	MRID 40098001 Mayer and Ellersieck (1996)
		95	Rainbow trout (*Salmo gairdneri*)	96-hr LC_{50} = **898** µg a.i./L[c] Highly toxic	MRID 40098001 Mayer and Ellersieck (1996)
		95	Largemouth bass (*Micropterus salmoides*)	96-hr LC_{50} (95% C.I.) = 1100 (1000-1200) µg a.i./L Moderately toxic	MRID 40098001 Mayer and Ellersieck (1996)
		99.6	Bluegill sunfish (*Lepomis macrochirus*)	96-hr LC_{50} (95% C.I.) = 5000 (4000-6300) µg a.i./L Probit slope (95% C.I.) = 4.4 (2.7-6.0) (0, 10, 20, 40, 70, 90, and 100% mortality at 1500, 2200, 3200, 4700, 6900, 10000, and 15000 µg a.i./L; sublethal effects: erratic swimming) Moderately toxic	MRID 00112840 Acceptable
		99.6	Rainbow trout (*Oncorhynchus mykiss*)	96-hr LC_{50} (95% C.I.) = 5900 (5100-6900) µg a.i./L Probit slope (95% C.I.) = 13.0 (5.4-20.6) (0, 10, 80, 100, and 100% mortality at 3200, 4700, 6900, 10000 and 15000 µg a.i./L; sublethal effects: erratic swimming, loss of reflex, and discoloration) Moderately toxic	MRID 00112840 Acceptable
		NA	Bluegill sunfish	Estimated chronic $NOAEC_{(bluegill\ sunfish)}$	NA

Assessment Endpoint	Measurement Endpoint	% a.i.	Species	Toxicity Endpoints[a,b] (Effects) & Acute Toxicity Classification (if applicable)	Source & Classification
	Most sensitive freshwater fish chronic NOAEC		(*Lepomis macrochirus*)	= Acute $LC_{50(\text{bluegill sunfish})}$ / $ACR_{(\text{rainbow trout})}$ = 340 µg/L / 77 = **4.4** µg/L *Where*: $ACR_{(\text{rainbow trout})}$ = Acute $LC_{50(\text{rainbow trout})}$ / Chronic $NOAEC_{(\text{rainbow trout})}$ = 898 µg/L / 1.6 µg/L = 77	
		96.2 (TGAI) 99.1 (Radio-labeled)	Rainbow trout (*Oncorhynchus mykiss*)	Early life-stage 62-day NOAEC = **11.7** µg a.i./L 62-day LOAEC = 24.6 µg a.i./L (based on most sensitive endpoints of length and weight; day 36 post-hatch survival and length also affected at ≥ 96.1 µg a.i./L; day 62 post-hatch survival also affected at ≥ 48.4898 µg a.i./L)	MRID 43066301 Acceptable
Survival, growth, and reproduction of estuarine/marine fish	Most sensitive estuarine/marine fish acute LC_{50}	95	Sheepshead minnow (*Cyprinodon variegatus*)	48-hr LC_{50} = **280** µg a.i./L (nom) Highly toxic	MRID 40228401 Mayer (1986)
	Most sensitive estuarine/marine fish chronic NOAEC	NA	Sheepshead minnow (*Cyprinodon variegatus*)	No data Estimated chronic $NOAEC_{(\text{sheepshead minnow})}$ = Acute $LC_{50(\text{sheepshead minnow})}$ / $ACR_{(\text{rainbow trout})}$ = 280 µg/L / 77 = **3.6** µg/L *Where*: $ACR_{(\text{rainbow trout})}$ = Acute $LC_{50(\text{rainbow trout})}$ / Chronic $NOAEC_{(\text{rainbow trout})}$ = 898 µg/L / 1.6 µg/L = 77	NA
Survival, growth, and reproduction of freshwater invertebrates	Most sensitive freshwater invertebrate acute EC_{50}	97	Scud (*Gammarus lacustris*)	96-hr LC_{50} (95% C.I.) = **0.074** (0.059-0.092) µg a.i./L 48-hr LC_{50} (95% C.I.) = 0.14 (0.082-0.24) µg a.i./L Very highly toxic	MRIDs 05009242 and 40098001 Supplemental (due to life stage tested – adult instead of immature)

Assessment Endpoint	Measurement Endpoint	% a.i.	Species	Toxicity Endpoints[a,b] (Effects) & Acute Toxicity Classification (if applicable)	Source & Classification
		95	Scud (*Gammarus fasciatus*)	96-hr LC_{50} (95% C.I.) = 0.15 (0.11-0.20) µg a.i./L Very highly toxic	MRID 05017538 Supplemental (due to life stage tested – adult instead of immature)
		99.64 (TGAI) 98.9 (Radio-labeled)	Water flea (*Daphnia magna*)	48-hr EC_{50} (95% C.I.) = 0.192 (0.134-0.240) µg a.i./L (mm)[d] Probit slope (95% C.I.) = 2.7 (1.7-3.7) 48-hr NOAEC < 0.106 µg a.i./L (mm) (30, 50, 65, 80, 85, and 100% immobility at 0.106, 0.210, 0.310, 0.415, 0.523, and 0.614 µg a.i./L) Very highly toxic	MRID 41778503 Supplemental (due to life stage tested – adult instead of < 24-hr old instar)
		99.64 (TGAI) 98.9 (Radio-labeled)	Scud (*Gammarus lacustris*)	48-hr EC_{50} (95% C.I.) = 0.224 (0.201-0.246) µg a.i./L (mm) Probit slope (95% C.I.) = 6.6 (5.0-8.3) 48-hr NOAEC = 0.103 µg a.i./L (mm) (0, 25, 35, 55, 80, 95, 100, 100, 100, 100, 100, and 100% immobility at 0.103, 0.154, 0.204, 0.255, 0.326, 0.371, 0.408, 0.514, 0.610, 0.708, and 0.806 µg a.i./L) Very highly toxic	MRID 41778504 Acceptable
	Most sensitive freshwater invertebrate chronic NOAEC	NA	Scud (*Gammarus fasciatus*)	Estimated chronic $NOAEC_{(G.\ lacustris)}$ = Acute $LC_{50(G.\ lacustris)}$ / $ACR_{(D.\ magna)}$ = 0.074 µg/L / 6 = **0.0127** µg/L *Where*: $ACR_{(D.\ magna)}$ = Acute $EC_{50(D.\ magna)}$ / Chronic $NOAEC_{(D.\ magna)}$ = 0.192 µg/L / 0.0337 µg/L = 6	NA
		99.1 (Radio-labeled)	Water flea (*Daphnia magna*)	21-day NOAEC = 0.0337 µg a.i./L (mm) 21-day LOAEC = 0.0758 µg a.i./L (mm) (NOAEC based on survival)	MRID 43116601 Acceptable
Survival, growth, and reproduction of estuarine/marine invertebrates	Most sensitive estuarine/marine invertebrate acute EC_{50} or LC_{50}	95	Pink shrimp (*Penaeus duorarum*)	48-hr EC_{50} = **2.0** µg a.i./L (nom) Very highly toxic	MRID 40228401 Mayer (1986)
		95	Eastern oyster	96-hr EC_{50} = 290 µg a.i./L (nom) at 221 ppt sal. and 9 °C 96-hr EC_{50} = 880 µg a.i./L (nom) at 23 ppt sal. and 9 °C	MRID 40228401 Mayer (1986)

Assessment Endpoint	Measurement Endpoint	% a.i.	Species	Toxicity Endpoints[a,b] (Effects) & Acute Toxicity Classification (if applicable)	Source & Classification
			(*Crassostrea virginica*)	Highly toxic	
	Most sensitive estuarine/marine invertebrate chronic NOAEC	NA	Pink shrimp (*Penaeus duorarum*)	Estimated chronic $NOAEC_{(pink\ shrimp)}$ = Acute $LC_{50(pink\ shrimp)}$ / $ACR_{(D.\ magna)}$ = 2.0 µg/L / 6 = **0.3421** µg/L *Where*: $ACR_{(D.\ magna)}$ = Acute $EC_{50(D.\ magna)}$ / Chronic $NOAEC_{(D.\ magna)}$ = 0.197 µg/L / 0.0337 µg/L = 6	NA
Survival, growth, and reproduction of benthic (sediment-dwelling) invertebrates	Most sensitive be benthic invertebrate acute EC_{50} or LC_{50} or sub-chronic NOAEC	No data			
	Most sensitive benthic invertebrate chronic NOAEC	No data			
Survival, growth and reproduction of aquatic plants	Aquatic non-vascular species: Most sensitive EC_{50}	No data			
	Aquatic vascular species: Most sensitive EC_{50}	95.7	Duckweed (*Lemna gibba*)	Tier II 7-dayEC_{50} > 166 µg a.i./L (mm) 7-day NOAEC = **166** µg a.i./L (mm) (no effects)	MRID 48322801 Supplemental (due to the number of plants per replicate being lower than recommended)

C.I. = confidence interval; NA = not applicable
[a] **BOLD** values used in RQ calculations
[b] mm = mean-measured; nom = nominal
[c] used to calculate freshwater fish acute to chronic ratio
[d] used to calculate freshwater invertebrate acute to chronic ratio

5.1.3 Freshwater Invertebrates

Based on studies with *Gammarus lacustris*, *Gammarus fasciatus*, and *Daphnia magna,* coumaphos is very highly toxic to freshwater invertebrates on an acute basis.

An acute study with the scud *G. lacustris* (MRID 05009242) yielded the most sensitive endpoint, *i.e.*, LC_{50} = 0.074 µg a.i./L. This study was classified as "supplemental" due to the life stage of the test organisms; adult individuals were used instead of immature individuals, which are recommended. A second study with *G. lacustris* (MRID 41778504), which is classified as "acceptable," had an EC_{50} of 0.224 µg a.i./L and a NOAEC of 0.103 µg a.i./L based on immobility.

An acute study with another species of scud, *G. fasciatus* (MRID 05017538), yielded an LC_{50} of 0.15 µg a.i./L. This study was classified as "supplemental" due to the life stage of the test organisms; adult individuals were used instead of immature individuals, which are recommended.

In the acute study with *D. magna* (MRID 41778503), the EC_{50} was 0.192 µg a.i./L, and the NOAEC was less than the lowest concentration tested, (*i.e.*, < 0.106 µg a.i./L). This study was classified as "supplemental" due to the life stage of the test organisms; adult individuals were used instead of < 24-hour old individuals, which are recommended.

In the chronic study with *D. magna* (MRID 43116601), the NOAEC of 0.0337 µg a.i./L was based on survival.

Since the freshwater invertebrate chronic toxicity endpoint of 0.0337 µg/L (*D. magna*; MRID 43116601) was not generated using the most acutely sensitive freshwater invertebrate (*i.e.*, *G. lacustris*), a chronic toxicity endpoint for *G. lacustris* of 0.0127 µg/L was calculated using the acute toxicity endpoint for *G. lacustris* and an ACR for *D. magna* (see **Table 5-1** for calculation).

5.1.4 Estuarine/Marine Invertebrates

Based on studies with pink shrimp and Eastern oyster (MRID 40228401), coumaphos is highly to very highly toxic to estuarine/marine invertebrates on an acute basis. These studies yielded EC_{50} endpoints of 2.0 and 290 µg a.i./L, respectively.

No data are available for the chronic toxicity of coumaphos to estuarine/marine invertebrates. Therefore, a chronic toxicity endpoint for estuarine/marine invertebrates of 0.3421 µg/L was calculated using the acute toxicity endpoint for pink shrimp and an ACR for freshwater invertebrates (*i.e.*, *D. magna*) (see **Table 5-1** for calculation).

5.1.5 Benthic (Sediment-Dwelling) Invertebrates

No data are available for the toxicity of coumaphos to benthic invertebrates.

5.1.6 Aquatic Plants

A Tier II study with *Lemna gibba* (MRID 43822801) submitted since the 2008 problem formulation yielded no effects resulting in an EC_{50} and NOAEC of > 166 and 166 µg a.i./L, respectively. This study was classified as "supplemental" due to the number of plants per replicate being lower than recommended.

No acceptable data are available for the toxicity of coumaphos to aquatic non-vascular plants. As noted previously, a study with *P. subcapitata* (MRID 48322802) submitted since the 2008 problem formulation was classified as "invalid" because the solvent had a stimulatory effect that could have masked the true effects of coumaphos. An EFED memo (DP 406398, October 31, 2012) proposed using data from a surrogate pesticide in lieu of requesting an additional non-vascular aquatic plant study. Specifically, the memo noted that aquatic non-vascular plant data are available for the following organophosphate insecticides: chlorpyrifos, diazinon, dichlorvos, dicrotophos, dimethoate, EPN, fenthion, naled, oxydemeton-methyl, phorate, and trichlorfon. Of the available data, naled is the most toxic to aquatic non-vascular plants. Thus, toxicity data for naled (**Table 5-2**) was used for characterizing the toxicity of coumaphos to aquatic non-vascular plants. The most sensitive definitive toxicity endpoints for naled (*i.e.*, EC_{50} = 24 µg a.i./L; NOAEC = 4.2 µg a.i./L) are bolded.

Table 5-2. Aquatic Plant Toxicity Profile for Naled

Species	% a.i.	Toxicity Values[a]	Source & Classification
Duckweed (*Lemna gibba)*	94.4	14-day EC_{50} > 1800 µg a.i./L 14-day NOAEC < 1800 µg a.i./L	MRID 42529601 Supplemental
Blue-green algae (*Anabaena flos-aquae)*	94.4	5-day EC_{50} (95% C.I.) = 91 (15-7400) µg a.i./L 5-day NOAEC = 57 µg a.i./L	MRID 42529604 Acceptable
Freshwater diatom (*Navicula pelliculosa)*	94.4	5-day EC_{50} (95% C.I.) = **24** (10-70) µg a.i./L 5-day NOAEC = **4.2** µg a.i./L	MRID 42529603 Acceptable
Green algae (*Selenastrum capricornutum)*	94.4	5-day EC_{50} (95% C.I.) = 40 (13-100) µg a.i./L 5-day NOAEC: Not reported	MRID 42529605 Acceptable
Marine diatom (*Skeletonema costatum)*	94.4	5-day EC_{50} (95% C.I.) = 50 (24-100) µg a.i./L 5-day NOAEC = 6.3 µg a.i./L	MRID 42529602 Acceptable

C.I. = confidence interval

[a] **BOLD** values used in risk characterization

5.2 Effects to Terrestrial Organisms

Summaries of data used to characterize the effects of coumaphos to terrestrial organisms are provided in **Table 5-3**. The most sensitive definitive toxicity endpoints used in RQ calculations are bolded.

Table 5-3. Endpoints Used to Characterize the Effects of Coumaphos to Terrestrial Organisms

Assessment Endpoint	Measurement Endpoint	% a.i.	Species	Toxicity Endpoints[1,2] (Effects) & Acute Toxicity Classification (if applicable)	Source & Classification
Survival, growth, and reproduction of birds (surrogate for reptiles and terrestrial-phase amphibians)	Most sensitive avian acute oral LD_{50}	98.25	Bobwhite quail (*Colinus virginianus*)	14-day LD_{50} (95% C.I.)= **2.4** (1.1-3.3) mg a.i./kg-bw (nom) Probit slope (95% C.I.) = 4.3 (1.2-7.3) (0, 40, 100, 100, and 100% mortality at 2, 4, 8, 16, 32 mg a.i,/kg-bw; all mortality occurred within the first 24 hours; sublethal effects: fluffed feathers in some birds of the 2 mg a.i./kg-bw treatment group; salivation, ataxia, wing drop, convulsions, and fluffed feathers in other treatment groups) Very highly toxic	MRID 00112843 Acceptable
		95	Ring-necked peasant (*Phasianus colchicus*)	14-day LD_{50} (95% C.I.) = 7.94 (5.73-11.0) mg a.i./kg-bw (nom) – females (mortality 2-3 hr after treatment; remission took up to 14 days; sublethal effects: spraddle-legged walking, wing twitching, slowness, hypoactivity, ataxia, wing-drop, falling, nutation, prostration with wings spread, lacrimation, immobility, wing-beat convulsions, and tetany appearing as soon as 90 minutes) Very highly toxic	MRID 00160000 Acceptable
		95	Mallard duck (*Anas platyrhynchos*)	14-day LD_{50} (95% C.I.) = 29.8 (21.5-41.3) mg a.i./kg-bw (nom) - males (mortality 2-3 hr after treatment; remission took up to 14 days; sublethal effects: spraddle-legged walking, wing twitching, slowness, hypoactivity, ataxia, wing-drop, falling, nutation, prostration with wings spread, lacrimation, immobility, wing-beat convulsions, and tetany appearing as soon as 40 minutes) Highly toxic	MRID 00160000 Acceptable
	Most sensitive avian sub-acute dietary LC_{50}	98.25	Bobwhite quail (*Colinus virginianus*)	8-day LC_{50} (95% C.I.) = **82.1** (67.6-99.7) mg a.i./kg-diet (nom) Probit slope (95% C.I.) = 6.6 (3.6-9.7) (0, 10, 20, 70, 100, 100, and 100% mortality at 30, 45, 68, 102, 153, 230, and 345 mg a.i./kg-diet; sublethal effects: ataxia, wing drop, convulsions, tremors, and diarrhea at $\geq$ 68 mg a.i./kg-diet; decrease in body weights at 45-153 mg a.i./kg-diet; concentration-dependent decrease in food consumption during the first 5 days for birds on treated feed) Highly toxic	MRID 00112843 Acceptable
		95	Bobwhite quail (*Colinus virginianus*)	8-day LC_{50} (95% C.I.) = 120 (104-139) mg a.i./kg-diet (nom) Probit slope (S.D.) = 7.348 (1.923) Highly toxic	MRID 00022923 Acceptable
		95	Japanese quail	8-dayLC_{50} (95% C.I.) = 225 (172-306) mg a.i./kg-diet (nom)	MRID 00022923

Assessment Endpoint	Measurement Endpoint	% a.i.	Species	Toxicity Endpoints[1,2] (Effects) & Acute Toxicity Classification (if applicable)	Source & Classification
			(*Coturnix japonica*)	Probit slope (S.D.) = 4.652 (1.049) Highly toxic	Acceptable
		95	Ring-necked peasant (*Phasianus colchicus*)	8-day LC_{50} (95% C.I.) = 318 (227-364) mg a.i./kg-diet (nom) Probit slope (S.D.) = 7.228 (1.452) Highly toxic	MRID 00022923 Acceptable
		98.25	Mallard duck (*Anas platyrhynchos*)	8-day LC_{50} (95% C.I.) = 402 (227-593) mg a.i./kg-diet (nom) Probit slope (95% C.I.) = 2.9 (1.7-4.2) (0, 0, 30, 50, 70, and 100% mortality at 50, 100, 200, 400, 800, and 1600 mg a.i./kg-diet; sublethal effects wing drop, salivation regurgitation, ataxia, nutation, and immobility at ≥ 200 mg a.i./kg-diet; decrease in body weights from day 0 to day 5 at ≥ 100 mg a.i./kg-diet; concentration-dependent decrease in food consumption during the first 5 days for birds on treated feed) Highly toxic	MRID 00112842 Acceptable
		95	Mallard duck (*Anas platyrhynchos*)	8-day LC_{50} (95% C.I.) = 709 (521-1032) mg a.i./kg-diet (nom) Probit slope (S.D.) = 1.981 (0.933) Moderately toxic	MRID 00022923 Acceptable
	Most sensitive avian chronic NOAEC	No data			
Survival, growth, and reproduction of mammals	Most sensitive mammalian acute LD_{50}	TGAI	Sprague-Dawley rat (*Rattus norvegicus*)	Females LD_{50} (95% C.I.) = **17** (14-22) mg/kg-bw Male LD_{50} > 240 mg/kg-bw (Mortality: females – 0, 0, 70, and 100% mortality at 5, 10, 20, and 40 mg/kg-bw; males – 0, 0, 0, 0, and 10% mortality at 7.5, 15, 30, 60, 120, and 240 mg/kg-bw; sublethal effects (not specified): females – 90, 100, 100, and 100% at 5, 10, 20, and 40 mg/kg-bw; males – 80, 100, 100, 100, 100, and 100% at 7.5, 15, 30, 60, 120, and 240 mg/kg-bw) Highly toxic	MRID 00110597
	Most sensitive mammalian chronic NOAEC	99	Sprague-Dawley rat (*Rattus norvegicus*)	Two-generation reproduction <u>Cholinesterase (ChE) inhibition</u> NOAEL = 1 mg/kg-diet (0.07 mg/kg-bw/day) LOAEL = 5 mg/kg-diet (0.30 mg/kg-bw/day) <u>Systemic/reproductive toxicity</u> NOAEC = **25** mg/kg-diet (1.79 mg/kg-bw/day) LOAEC > 25 mg/kg-diet (1.79 mg/kg-bw/day) (no effects)	MRID 43061701

Assessment Endpoint	Measurement Endpoint	% a.i.	Species	Toxicity Endpoints[1,2] (Effects) & Acute Toxicity Classification (if applicable)	Source & Classification
Survival, growth, and reproduction of non-target terrestrial invertebrates	Most sensitive terrestrial invertebrate (*e.g.*, honey bee) acute LD_{50}	See **Section 5.2.3**			
Survival, growth and reproduction of terrestrial plants	Seedling emergence: Most sensitive monocot and dicot EC_{25} and NOAEC	No data			
	Vegetative vigor: Most sensitive monocot and dicot EC_{25} and NOAEC	No data			

NS = not specified; C.I. = confidence interval
[1] **BOLD** values used in RQ calculations
[2] nom = nominal

5.2.1 Birds

Based on studies with bobwhite quail, ring-necked peasant, and mallard duck, coumaphos is highly toxic to very highly toxic to birds on an acute oral basis.

In the acute oral study with bobwhite quail (MRID 00112843), the LD_{50} was 2.4 mg a.i./kg-bw, and all mortality occurred within the first 24 hours. Sublethal effects in the lowest treatment group of 2 mg a.i./kg-bw (100% survival) included fluffed feathers in some birds. Salivation, ataxia, wing drop, convulsions, and fluffed feathers were observed in the other treatment groups.

In acute oral studies with ring-necked peasant and mallard duck (MRID 01600000), the LD_{50}'s were 7.97 and 29.8 mg a.i./kg-bw, respectively. Mortality occurred within 2 to 3 hours after treatment, and remission took up to 14 days. Sublethal effects including spraddle-legged walking, wing twitching, slowness, hypoactivity, ataxia, wing-drop, falling, nutation, prostration with wings spread, lacrimation, immobility, wing-beat convulsions, and tetany appeared as soon as 90 and 40 minutes after dosing in ring-necked peasants and mallard ducks, respectively.

Based on studies with bobwhite quail, Japanese quail, ring-necked pheasant, and mallard duck, coumaphos is moderately to highly toxic to birds on a sub-acute dietary basis.

In the sub-acute dietary study with bobwhite quail that yielded the most sensitive endpoint (MRID 00112843), the LC_{50} was 82.1 mg a.i./kg-diet. Sublethal effects included ataxia, wing drop, convulsions, tremors, and diarrhea at $\geq$ 68 mg a.i./kg-diet and a decrease in body weights at 45-153 mg a.i./kg-diet. A concentration-dependent decrease in food consumption was also observed during the first 5 days for birds on treated feed.

In sub-acute dietary studies with bobwhite quail, Japanese quail, and mallard duck (MRID 00022923), the LC_{50}'s were 120, 225, and 709 mg a.i./kg-diet. Sublethal effects were not specified for these studies.

In another sub-acute dietary study with mallard duck (MRID 00112842), the LC_{50} was 402 mg a.i./kg-diet. Sublethal effects included wing drop, salivation, regurgitation, ataxia, nutation, and immobility at $\geq$ 200 mg a.i./kg-diet and a decrease in body weights from day 0 to day 5 at $\geq$ 100 mg a.i./kg-diet. A concentration-dependent decrease in food consumption was also observed during the first 5 days for birds on treated feed.

There are no data available for the chronic, reproductive toxicity of coumaphos to birds. In the absence of data specific to coumaphos, avian chronic toxicity data for surrogate organophosphate insecticides – specifically phosphorothioates – were used to characterize the chronic toxicity of coumaphos to birds. Phosphorothionate were selected because they are most likely to have physico/physiochemical properties that are similar to those of coumaphos. Avian chronic, reproductive toxicity data are available for the following phosphorothionate insecticides: fenitrothion, methyl parathion, and parathion (**Table 5-4**). Of the available data, parathion is the most toxic to birds on a chronic basis. Thus, the most sensitive chronic avian toxicity endpoint for parathion (*i.e.*, NOAEC = 2.85 mg/kg-diet) was used for characterizing the chronic toxicity of coumaphos to birds.

Table 5-4. Toxicity Data for Surrogate Organophosphorothionate Insecticides

Chemical PC Code	Species	NOAEC[a] (mg/kg-diet)	MRID & Classification
Fenitrothion 105901	Bobwhite quail (*Colinus virginianus*)	13	41958401 Acceptable
	Mallard duck (*Anas platyrhynchos*)	40	00262755 Acceptable
Methyl parathion 53501	Bobwhite quail (*Colinus virginianus*)	6.3	41179302 Acceptable
	Mallard duck (*Anas platyrhynchos*)	14.7	41179301 Supplemental
Parathion 57501	Bobwhite quail (*Colinus virginianus*)	8	41133102 Supplemental
	Mallard duck (*Anas platyrhynchos*)	**2.85**	41133101 Acceptable

[a] **BOLD** value used in risk characterization

5.2.2 Mammals

Based on a study with rat, coumaphos is highly toxic to mammals on an acute oral basis. In this acute oral study with rats (MRID 00110597), females were the more sensitive sex with an LD_{50} of 17 mg/kg-bw. Sublethal effects were not specified.

In a rat two-year generation reproduction study (MRID 43061701), cholinesterase inhibition was observed at 5 and 25 ppm and was manifested as dose-dependent decreases in erythrocyte (RBC) and plasma cholinesterase (ChE). Relative to concurrent controls, RBC ChE was inhibited 31-70% at 5 ppm and 53-95% at 25 ppm. Generally, no differences were noted between Day 47 (or 56) and Day 91 ChE levels. Brain levels were significantly inhibited (30%) in F_0 and F_1 females. In pups, plasma and RBC ChE levels were inhibited (31-44%) at 25 ppm on lactation day 21 but not on lactation day 4. Based on these results, the NOAEL and LOAEL for ChE inhibition were 1 and 5 ppm, respectively. There were no other signs of systemic toxicity. The NOAEL and LOAEL for systemic toxicity were equal to and greater than 25 ppm, respectively. Reproductive toxicity was not observed in this study. Consequently, the NOAEL for reproductive toxicity was 25 ppm, and the LOAEL for reproductive toxicity was greater than 25 ppm.

5.2.3 Non-Target Terrestrial Invertebrates

Data from guideline studies with honey bees are not available. However, three registrant-submitted studies evaluating the efficacy of coumaphos-impregnated strips to control mites in honey bee hives in Guatemala (MRID 45752811), Minnesota (MRID 45752812), and Nebraska (MRID 45752810) as well as an abstract of published research describing the control of the small hive beetles in hives treated with coumaphos-impregnated strips (MRID 45752813) have been reviewed and classified as "supplemental" (**Table 5-5**). In general, coumaphos was efficacious when impregnated strips contained a concentration of 5 or 10% active ingredient. It should be noted that in the three varroa mite efficacy studies, fluvalinate (formulated into Apistan strips) was used *following* treatment with coumaphos strips and in control groups but had no apparent effect on mite control.

In one of the varroa mite studies (MRID 45752812), bee mortality was quantified and did not appear to be different between control and treated hives (**Table 5-5**). In the other two varroa mite studies, the study authors stated that no unusual bee mortality was observed following treatment with coumaphos strips without further quantification (duration: 37-46 days; MRIDs 47572810 and 47572811). Bee mortality was not reported in the small hive beetle study (duration: 72 hours; MRID 45752812). These studies were not designed to measure other endpoints related to hive health and long-term effects (following the treatment period). Thus, there is uncertainty regarding the effects of coumaphos on brood, as well as the long-term stability of the hive.

Table 5-5. Summary of Observations of the Effect of Coumaphos on Bees Obtained from Efficacy Studies

Study Type	Species	Summary	Source & Classification
Non-guideline: Efficacy of Coumaphos Impregnated Strips for the Control of Varroa Mite	Honey bee (*Apis mellifera*)	No unusual bee mortality or injury to the colonies was observed during treatment (37 days) with coumaphos strips.	MRID 45752810 Supplemental
Non-guideline: Efficacy of Coumaphos Impregnated Strips for the Control of Varroa Mite	Honey bee (*Apis mellifera*)	No unusual adult bee mortality was observed during treatment (46 days) with the coumaphos strips.	MRID 45752811 Supplemental
Non-guideline: Efficacy of Coumaphos Impregnated Strips for the Control of Varroa Mite	Honey bee (*Apis mellifera*)	No unusual bee mortality or injury to the colonies was observed during treatment (46 days, but only 36 days of bee mortality observations) with coumaphos strips (control group: 329 dead bees, 2.5% group: 348 dead bees, 5% group = 373 dead bees, 10% group: 319 dead bees). However, six colonies died due to starvation (one in control, two in 2.5% coumaphos treatment, two in 5% coumaphos treatment, and one in 10% coumaphos treatment).	MRID 45752812 Supplemental
Non-guideline: Efficacy of Coumaphos Impregnated Strips for the Control of Small Hive Beetle	Honey bee (*Apis mellifera*)	No reports were made regarding observations of bee mortality or hive health during treatment (72 hours).	MRID 45752813 Supplemental

Data on the effects of coumaphos on the survival, growth, and/or reproduction of honey bees (*Apis mellifera*) are available from five open literature studies as identified via ECOTOX[17] (**Table 5-6**).

Table 5-6. Summary of Observations of the Effect of Coumaphos on Bees Obtained from Open Literature Studies as Identified via ECOTOX

Study Type	Species	Route of Exposure & Toxicity Values	ECOTOX No. & Classification
Non-guideline: Effects of coumaphos on queen rearing	Honey bee (*Apis mellifera*)	Impregnated strips Not applicable[a]	E066848 Qualitative

[17] http://cfpub.epa.gov/ecotox/

Study Type	Species	Route of Exposure & Toxicity Values	ECOTOX No. & Classification
Non-guideline: Effects of coumaphos on queen rearing	Honey bee (*Apis mellifera*)	Beeswax in queen cups 10-day NOAEC = 10 mg/kg 10-day LOAEC = 100 mg/kg (based on rejection of transferred larvae and reduced weight of queen pupae)	E100380 Quantitative
Non-guideline: Effects of coumaphos on queen rearing	Honey bee (*Apis mellifera*)	Beeswax in queen cups 10-day NOAEC = 10 mg/kg 10-day LOAEC = 100 mg/kg (based on rejection of transferred larvae and reduced weight of queen pupae)	E100910 Quantitative
Non-guideline: Acute and chronic toxicity of coumaphos (as well as effects of coumaphos on hemolymph volume and *Nosema* infection) in the laboratory	Honey bee (*Apis mellifera*)	Oral 48-hr LD_{50} = 2.99 µg/bee for 8 day old bees 48-hr LD_{50} = 3.10 µg/bee for 14 day old bees 48-hr LD_{50} = 6.04 µg/bee for 3 day old bees	E101175 Quantitative
Non-guideline: Synergistic interactions of coumaphos and tau-fluvalinate in the laboratory	Honey bee (*Apis mellifera*)	Contact (application to thorax) 24-hr LD_{50} = 20.39 µg/bee	E119503 Qualitative

[a] There were only 2 treatment groups, and effects were seen in both groups relative to the control. Therefore, it was not possible to establish NOAECs or concentration-response relationships.

Three of the studies evaluated the effects of coumaphos on queen rearing. In E066848, honey bee colonies were treated with coumaphos-impregnated strips and monitored in two separate experiments (see **Section 4.3.4** for additional experimental details). There was high mortality in developing queens in colonies treated with ≥ 1 coumaphos strips for more than 24 hours. Physical abnormalities and atypical behavior were observed in queens due to inclusion of coumaphos strips in colonies. Queen weights and ovary weights were also significantly lower in treatment groups than the control group. Coumaphos concentrations increased in the bees and wax after treatments (see **Section 4.3.4** for concentrations). This study was classified as "qualitative" for use in the assessment because only two treatment groups were assessed, and effects were seen in both groups relative to the control. Therefore, it was not possible to establish NOAECs or concentration-response relationships.

In E100910, young honey bee larvae were transferred into queen cups containing 0 (control), 1, 10, 100, 300, 600, and 1000 mg/kg coumaphos. The cups with larvae were then placed in queenless colonies and examined after 10 days to determine the rejection rate of transferred larvae and weight of queen pupae. At ≥ 100 mg/kg, there was a significant rejection of larvae compared to control larvae. In addition, there was a significant reduction in the weight of queen pupae at 100 mg/kg compared to the control after 10 days. The 1 and 10 mg/kg treatment groups were not significantly different than the control for either endpoint. This study was classified as "quantitative" for use in the assessment.

In E100380, young honey bee larvae were transferred into queen cups containing 0 (control), 1, 10, 100, and 1000 mg/kg coumaphos. The cups with larvae were then placed in queenless colonies and examined after 10 days to determine the rejection rate of transferred larvae and weight of queen pupae. The queen cells were then placed in small mating colonies and examined after 21 days to determine commercial acceptability and mating success based on sperm count. Finally, the queens were introduced to production colonies and monitored for six months. For rejection rate and weight of queen pupae, significant effects were observed in the 100 and 1000 mg/kg coumaphos treatment groups when compared to the control. The 1 and 10 mg/kg treatment groups were not significantly different than the control for either endpoint. Mean sperm count was not significantly different among the control and 1, 10, and 100 mg/kg treatment groups, although there were significant differences between spermatheca color groups. Although not statistically significant, the percentage of queens from the 100 mg/kg treatment group surviving for 2-6 months in the production colony was less than that of queens from the control and 10 mg/kg treatment group. This study was classified as "quantitative" for use in the assessment.

One study (E119503) evaluated the effects of coumaphos and the pyrethroid tau-fluvalinate administered individually and in combination via contact exposure. Specifically, 3 to 4 day old worker bees were treated with 0 (solvent control), 0.1, 0.3, 1, 3, and 10 µg/bee via application to the thorax with or without pretreatment with enzyme inhibitors DEM, DEF, or PBO or tau-fluvalinate. Mortality was recorded 24 hours after treatment. The LD_{50} of coumaphos in the absence of enzyme inhibitors was 20.39 µg/bee. DEM did not alter the toxicity of coumaphos, but DEF and PBO enhanced the toxicity of coumaphos by 2.8-fold and 4-fold, respectively. When tau-fluvalinate was used as a pretreatment, the toxicity of coumaphos increased by 3.4-fold. This study was classified as "qualitative" for use in the assessment because the experimental design included a solvent control group but did not include a negative control group.

One study (E101175) examined the toxicity of coumaphos from acute oral and chronic exposures. For the acute toxicity tests, 3, 8, or 13 day old bees were fed 10 µL of 0.79 M sucrose solution containing 0, 0.8, 1.6, 3.2, 4.8, 6.4, or 8.0 µg coumaphos. Mortality was recorded 16, 24, 32, and 48 hours after feeding. For the chronic toxicity test, mixed age bees were fed a 2% coumaphos solution for 7 days, and mortality was recorded. Only a few bees fed coumaphos survived up to 12, 16, and 24 hours in the acute toxicity tests. The LD_{50} for 3 day old bees was 6.04 µg/bee, whereas the LD_{50}'s for 8 and 14 day old bees were 2.99 and 3.10 µg/bee, respectively. During chronic exposure, bees showed 50% mortality at day 7, which corresponded to 3 µg/bee/day. This study was classified as "quantitative" for use in the assessment.

5.2.4 Terrestrial (Upland and Semi-Aquatic) Plants

No data are available for the toxicity of coumaphos to terrestrial plants. Terrestrial plant toxicity data are available for the following organophosphate insecticides: diazinon, disulfoton, fosthiazate, isofenfos, and profenofos (see USEPA, 2010 for discussion of data). Of the available data, profenofos is the most toxic to terrestrial plants. Thus, toxicity data for profenofos (**Table 5-7**) was used for characterizing the toxicity of coumaphos to terrestrial plants.

Table 5-7. Terrestrial Plant Toxicity Data for Profenofos

Study Type	Toxicity Endpoints	Source
Seedling emergence	Most sensitive monocot: None	MRID 41627307

Study Type	Toxicity Endpoints	Source
Tier 2	EC_{25} > 1 lb a.i./A NOAEC = 1 lb a.i./A Most sensitive dicot: Cucumber (*Cucumis sativus*) EC_{25} = 0.13 lb a.i./A NOAEC = 0.111 lb a.i./A	Acceptable
Vegetative vigor Tier 2	Most sensitive species: None (4 monocots and 6 dicots) EC_{25}: Could not be determined due to lack of concentration response NOAEC = 1.0 lb a.i./A	MRID 41627305 Acceptable

5.3 Incident Database Review

Reviews of the Ecological Incident Information System (EIIS, version 2.1.1), which is maintained by the Agency's Office of Pesticide Programs, and the Avian Monitoring Information System (AIMS), which is maintained by the American Bird Conservatory, on May 31, 2013 yielded incidents involving terrestrial animals.

Two of the incidents involved birds:

- In a letter dated January 7, 1983, the U.S. Fish and Wildlife Service (USFWS) reported an unknown number of American wigeon(s) (*Anas americana*) was found dead in November 1981 in Washington state near a pond adjacent to a feedlot (EIIS B0000-400-27 and AIMS). The cause of death was attributed to coumaphos. However, information on the exposure pathway was not provided.
- The Canadian Wildlife Service and USFWS reported that one bald eagle (*Haliaeetus leucocephalus*) was observed dead or dying in Natrona County, Wyoming on March 2, 1986 (AIMS). Investigators were certain that coumaphos was responsible for this incident based on detection of coumaphos in gut contents and quantification of brain cholinesterase activity.

The remaining incidents involved honey bees:

- Eight kills of honey bees (*Apis mellifera*) from September 2001 to September 2002 were reported by the Minnesota Department of Agriculture (EIIS I014202-02, I014202-03, I014202-04, I014202-05, I014202-07, I014202-08, I014202-09, I014202-17). In all of these incidents, residue analyses detected coumaphos in bee tissue and/or pollen. No other pesticides were detected. Investigators concluded that insufficient evidence was available to determine if the exposure to coumaphos played a role in these bee kills or was merely incidental.
- In June 2009, after the aerial application of the active ingredients carbaryl, potassa, fenoxaprop-ethyl to crop fields in Box Elder County, UT, 30% of the bee hives (*Apis mellifera*) died within a month (EIIS I021587-001). Subsequently, there were 3 more applications at bloom with Warrior (active ingredient: 22.8% *lambda*-cyhalothrin) through August. By December of 2009, 320 hives collapsed. Lab testing detected 14 different active ingredients including coumaphos in bee tissue and/or bee wax.

In addition to the incidents recorded in EIIS and AIMS, additional incidents are reported to the Agency in aggregated form. Pesticide registrants report certain types of incidents to the Agency as aggregate counts of incidents occurring per product per quarter. Ecological incidents reported in aggregate reports include those categorized as 'minor fish and wildlife' (W-B), 'minor plant' (P-B), and 'other non-target' (ONT) incidents. 'Other non-target' incidents include reports of adverse effects to insects and other terrestrial invertebrates. For coumaphos, registrants have reported no minor fish and wildlife incidents, no minor plant incidents, and one other non-target incident as of June 4, 2013. The minor other non-target incident involved the use of Checkmite (bee strip).

The total number of actual incidents associated with the use of coumaphos may be higher than what is reported to the Agency. Incidents may go unreported since effects may not be immediately apparent and/or readily attributed to the use of a chemical.

6 Risk Characterization

6.1 Risk Estimation

Estimates of exposure and toxicity of coumaphos are integrated using standard risk quotient (RQ) methods to evaluate the potential for adverse ecological effects to mammalian, avian, aquatic, and other non-target species. RQ results for non-target terrestrial and aquatic animals and plants are described in this section and represent expected direct effects to organisms (*i.e.*, effects from direct toxicity to coumaphos exposure) in contrast to indirect effects to organisms resulting from a modification of a resource such as loss of their prey or habitat.

6.1.1 Direct Effects to Aquatic Organisms

Risk to aquatic organisms from exposure via runoff (CAFO manure applied to land, non-regulated small CAFO, rangeland) was estimated using EECs from PRZM/EXAMS modeling.

Risk to aquatic organisms from exposure via wash-off from the skin of treated livestock that enter bodies of water was estimated in two ways. First, RQs for wash-off from one cow entering a 1 acre, 6 foot deep body of water were calculated using EECs in **Tables 4-8** and **4-10** (*i.e.*, EEC/cow) and the following formula:

$$\text{RQ/cow} = (\text{EEC/cow in } \mu\text{g/L}) \,/\, (\text{Toxicity endpoint in } \mu\text{g/L})$$

Second, the number of cows entering a 1 acre, 6 foot deep body of water that would cause an LOC exceedance was calculated using the following formula:

$$\text{Number of cows to cause LOC exceedance} = \text{LOC} \,/\, (\text{RQ/cow})$$

6.1.1.1 Fish and Aquatic-Phase Amphibians

Freshwater fish acute RQs were calculated using the most sensitive acute toxicity endpoint of 340 µg/L (bluegill sunfish; MRID 40098001); freshwater fish chronic RQs were calculated using an estimated chronic toxicity endpoint (for bluegill sunfish) of 4.4 µg/L (**Tables 6-1** and **6-2**).

Freshwater fish acute and chronic RQs for runoff range are <0.01 and <0.01 to 0.05 respectively. There are no freshwater fish acute or chronic LOC exceedances for runoff.

Freshwater fish acute and chronic RQs for wash-off from one cow entering a 1 acre, 6 foot deep body of water are <0.01. Hundreds of cows would need to enter a 1 acre, 6 foot deep body of water to cause an acute or chronic LOC exceedance for freshwater fish.

Table 6-1. Freshwater Fish Risk Quotients (RQs) for Runoff

PRZM/EXAMS Scenarios	Sources of a.i. from Application Scenario	Wash-Off Fraction	Acute RQ	Chronic RQ
Texas: Spray Application (42% flowable concentrate)				
BSSTurf	Runoff from CAFO manure applied to land (No incorporation of manure into soil)	0.02	<0.01	0.01
	Runoff from non-regulated small CAFO	0.02	<0.01	0.04
RangeBSS	Runoff from rangeland	0.02	<0.01	<0.01
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)				
PA Turf	Runoff from CAFO manure applied to land (No incorporation of manure into soil)	0.027	<0.01	0.01
	Runoff from non-regulated small CAFO	0.027	<0.01	0.05
	Runoff from rangeland	0.027	<0.01	<0.01

6-2. Freshwater Fish Risk Quotients (RQs) for Wash-Off from Treated Livestock That Enter Bodies of Water

Maximum Application Rate			Wash-Off Fraction	Acute RQ/cow	Number of Cows to Cause Acute LOC Exceedance		Chronic RQ/cow	Number of Cows to Cause Chronic LOC Exceedance
Type	(lb a.i./ animal)	(mg a.i./ ft^2 cow hide)			Listed	Non-Listed		Listed & Non-Listed
Texas: Dip Vat Application (42% flowable concentrate)								
Single	0.027	272	0.02	<0.01	1308	13077	<0.01	550
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)								
Single	0.01	101	0.027	<0.01	2429	24286	<0.01	1100

Estuarine/marine fish acute RQs were calculated using the most sensitive acute toxicity endpoint of 280 µg/L (sheepshead minnow; MRID 40228401); estuarine/marine fish chronic RQs were calculated using an estimated chronic toxicity endpoint (for sheepshead minnow) of 3.6 µg/L (**Table 6-3** and **6-4**).

Estuarine/marine fish acute and chronic RQs for runoff are <0.01 and <0.01 to 0.06, respectively. There are no estuarine/marine fish acute or chronic LOC exceedances for runoff.

Estuarine/marine fish acute and chronic RQs for wash-off from one cow entering a 1 acre, 6 foot deep body of water are <0.01. Hundreds of cows would need to enter a 1 acre, 6 foot deep body of water to cause an acute or chronic LOC exceedance for estuarine/marine fish.

Table 6-3. Estuarine/Marine Fish Risk Quotients (RQs) for Runoff

PRZM/EXAMS Scenarios	Sources of a.i. from Application Scenario	Wash-Off Fraction	Acute RQ	Chronic RQ
Texas: Spray Application (42% flowable concentrate)				
BSSTurf	Runoff from CAFO manure applied to land (No incorporation of manure into soil)	0.02	<0.01	0.01
	Runoff from non-regulated small CAFO	0.02	<0.01	0.05
RangeBSS	Runoff from rangeland	0.02	<0.01	<0.01
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)				
PA Turf	Runoff from CAFO manure applied to land (No incorporation of manure into soil)	0.027	<0.01	0.01
	Runoff from non-regulated small CAFO	0.027	<0.01	0.06

PRZM/EXAMS Scenarios	Sources of a.i. from Application Scenario	Wash-Off Fraction	Acute RQ	Chronic RQ
	Runoff from rangeland	0.027	<0.01	<0.01

Table 6-4. Estuarine/Marine Fish Risk Quotients (RQs) for Wash-Off from Treated Livestock That Enter Bodies of Water[a]

Maximum Application Rate			Wash-Off Fraction	Acute RQ/cow	Number of Cows to Cause Acute LOC Exceedance		Chronic RQ/cow	Number of Cows to Cause Chronic LOC Exceedance
Type	(lb a.i./ animal)	(mg a.i./ ft² cow hide)			Listed	Non-Listed		Listed & Non-Listed
Texas: Dip Vat Application (42% flowable concentrate)								
Single	0.027	272	0.02	<0.01	1077	10769	<0.01	450
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)								
Single	0.01	101	0.027	<0.01	2000	20000	<0.01	900

[a] 1 acre, 6 foot deep body of water

6.1.1.2 Aquatic Invertebrates

Freshwater invertebrate acute RQs were calculated using the most sensitive acute toxicity endpoint of 0.074 µg/L (*G. lacustris*; MRIDs 05009242 and 40098001); freshwater invertebrate chronic RQs were calculated using an estimated chronic toxicity endpoint (for *G. lacustris*) of 0.0127 µg/L (**Table 6-5** and **6-6**).

Freshwater invertebrate acute and chronic RQs for runoff range from 0.02 to 3.4 and 0.09 to 17, respectively. There are multiple acute and chronic exceedances across runoff exposure pathways for both Texas and the rest of the U.S.

Freshwater invertebrate acute RQs for wash-off from one cow entering a 1 acre, 6 foot deep body of water are 0.11 and 0.05 for Texas and the rest of the U.S., respectively, whereas chronic RQs for wash-off from one cow entering a 1 acre, 6 foot deep body of water are 0.63 to 0.31 for Texas and the rest of the U.S., respectively. Only one and five to ten cows would need to enter a 1 acre, 6 foot deep body of water to cause acute LOC exceedances for listed and non-listed freshwater invertebrates, respectively. Only two and four cows would need to enter the same body of water to cause a chronic LOC exceedance for freshwater invertebrates in Texas and the rest of the U.S., respectively.

Table 6-5. Freshwater Invertebrate Risk Quotients (RQs) for Runoff

PRZM/EXAMS Scenarios	Sources of a.i. from Application Scenario	Wash-Off Fraction	Acute RQ	Chronic RQ
Texas: Spray Application (42% flowable concentrate; 3 applications @ 0.021 lb/AU)				
BSSTurf	Runoff from CAFO manure applied to land	No incorporation of manure into soil		
		0.02	**0.68****	**2.4*****
		Incorporation of manure into soil within a day		
		0.02	0.04	0.17
	Runoff from non-regulated small CAFO	0.02	**3.4****	**17*****
RangeBSS	Runoff from rangeland	0.02	**0.07***	0.31
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration; 6 applications @ 0.00829 lb/AU)				
PA Turf	Runoff from CAFO manure applied to land	No incorporation of manure into soil		

PRZM/EXAMS Scenarios	Sources of a.i. from Application Scenario	Wash-Off Fraction	Acute RQ	Chronic RQ
		0.027	**0.54****	**2.4*****
		Incorporation of manure into soil within a day		
		0.027	0.03	0.14
	Runoff from non-regulated small CAFO	0.027	**3.9****	**18*****
	Runoff from rangeland	0.027	0.02	0.09

*exceeds aquatic animal acute listed species LOC (=0.05)
**exceeds aquatic animal acute non-listed species LOC (=0.5)
*** exceeds aquatic animal chronic listed and non-listed species LOC (=1)

Table 6-6. Freshwater Invertebrate Risk Quotients (RQs) for Wash-Off from Treated Livestock That Enter Bodies of Water[a]

Maximum Application Rate			Wash-Off Fraction	Acute RQ/cow	Number of Cows to Cause Acute LOC Exceedance		Chronic RQ/cow	Number of Cows to Cause Chronic LOC Exceedance
Type	(lb a.i./ animal)	(mg a.i./ ft^2 cow hide)			Listed	Non-Listed		Listed & Non-Listed
Texas: Dip Vat Application (42% flowable concentrate)								
Single	0.027	272	0.02	0.11	<1	5	0.63	2
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)								
Single	0.01	101	0.027	0.05	<1	10	0.31	4

[a] 1 acre, 6 foot deep body of water

Estuarine/marine invertebrate acute RQs were calculated using the most sensitive acute toxicity endpoint of 2.0 μg/L (pink shrimp; MRID 40228401); estuarine/marine invertebrate chronic RQs were calculated using the estimated chronic toxicity endpoint (for pink shrimp) of 0.3421 μg/L (**Table 6-7** and **6-8**).

Estuarine/marine invertebrate acute and chronic RQs for runoff range from <0.01 to 0.15 and <0.01 to 0.67, respectively. The only LOC exceedances are for acute exposure via runoff from non-regulated small CAFO for listed species of estuarine/marine invertebrates.

Estuarine/marine invertebrate acute RQs for wash-off from one cow entering a 1 acre, 6 foot deep body of water are <0.01 for Texas and the rest of the U.S. whereas chronic RQs for wash-off from one cow entering a 1 acre, 6 foot deep body of water are 0.02 to 0.01 for Texas and the rest of the U.S., respectively. Only 13 to 25 cows would need to enter a 1 acre, 6 foot deep body of water to cause acute LOC exceedances for listed estuarine/marine invertebrates whereas over a hundred cows would need to enter a 1 acre, 6 foot deep body of water to cause acute LOC exceedances for non-listed freshwater invertebrates. At least 43 and 86 cows would need to enter the same body of water to cause a chronic LOC exceedance for estuarine/marine invertebrates in Texas and the rest of the U.S., respectively.

Table 6-7. Estuarine/Marine Invertebrate Risk Quotients (RQs) for Runoff

PRZM/EXAMS Scenarios	Sources of a.i. from Application Scenario	Wash-Off Fraction	Acute RQ	Chronic RQ
Texas: Spray Application (42% flowable concentrate)				
BSSTurf	Runoff from CAFO manure applied to land	No incorporation of manure into soil		
		0.02	0.03	0.09
		Incorporation of manure into soil within a day		
		0.02	<0.01	0.01
	Runoff from non-regulated small CAFO	0.02	**0.13***	0.61
RangeBSS	Runoff from rangeland	0.02	<0.01	0.01
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)				
PA Turf	Runoff from CAFO manure applied to land	No incorporation of manure into soil		
		0.027	0.02	0.09
		Incorporation of manure into soil within a day		
		0.027	<0.01	0.01
	Runoff from non-regulated small CAFO	0.027	**0.15***	0.67
	Runoff from rangeland	0.027	<0.01	<0.01

*exceeds aquatic animal acute listed species LOC (=0.05)

6-8. Estuarine/Marine Invertebrate Risk Quotients (RQs) for Wash-Off from Treated Livestock That Enter Bodies of Water

Maximum Application Rate			Wash-Off Fraction	Acute RQ/cow	Number of Cows to Cause Acute LOC Exceedance		Chronic RQ/cow	Number of Cows to Cause Chronic LOC Exceedance
Type	(lb a.i./ animal)	(mg a.i./ ft^2 cow hide)			Listed	Non-Listed		Listed & Non-Listed
Texas: Dip Vat Application (42% flowable concentrate)								
Single	0.027	272	0.02	<0.01	13	125	0.02	43
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)								
Single	0.01	101	0.027	<0.01	25	250	0.01	86

[a] 1 acre, 6 foot deep body of water

Since no data are available for the toxicity of coumaphos to benthic (sediment-dwelling) invertebrates, acute and chronic RQs for benthic invertebrates (**Tables 6-9** and **6-10**) were calculated using the most sensitive water column acute and chronic toxicity endpoints for coumaphos (*i.e.*, 0.074 and 0.0127 µg/L, respectively).

Benthic invertebrate acute and chronic RQs for runoff range from 2.3 to 2.6 and 13 to 15, respectively. All benthic invertebrate RQs for runoff from a non-regulated small CAFO exceed LOCs.

Benthic invertebrate acute RQs for wash-off from one cow entering a 1 acre, 6 foot deep body of water range from 0.04 to 0.07 whereas chronic RQs for wash-off from one cow entering a 1 acre, 6 foot deep body of water range from 0.24 to 0.55. Less than 13 cows would need to enter a 1 acre, 6 foot deep body of water to cause acute and chronic LOC exceedances for listed and non-listed benthic invertebrates.

Table 6-9. Benthic Invertebrate Risk Quotients (RQs) for Runoff

PRZM/EXAMS Scenarios	Sources of a.i. from Application Scenario	Wash-Off Fraction	Acute RQ	Chronic RQ
Texas: Spray Application (42% flowable concentrate; 3 applications @ 0.021 lb/AU)				
BSSTurf	Runoff from non-regulated small CAFO	0.02	**2.3****	**13*****
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration; 6 applications @ 0.00829 lb/AU)				
PA Turf	Runoff from non-regulated small CAFO	0.03	**2.6****	**15*****

**exceeds aquatic animal acute non-listed species LOC (=0.5)
*** exceeds aquatic animal chronic listed and non-listed species LOC (=1)

6-10. Benthic Invertebrate Risk Quotients (RQs) for Wash-Off from Treated Livestock That Enter Bodies of Water

Maximum Application Rate			Wash-Off Fraction	Acute RQ/cow	Number of Cows to Cause Acute LOC Exceedance		Chronic RQ/cow	Number of Cows to Cause Chronic LOC Exceedance
Type	(lb a.i./ animal)	(mg a.i./ ft^2 cow hide)			Listed	Non-Listed		Listed & Non-Listed
Texas: Dip Vat Application (42% flowable concentrate)								
Single	0.027	272	0.02	0.07	<1	8	0.55	2
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)								
Single	0.01	101	0.027	0.04	<1	13	0.24	5

[a] 1 acre, 6 foot deep body of water

6.1.1.3 Aquatic Plants

RQs for aquatic non-vascular plants for exposure via runoff and wash-off were not calculated because of the lack of toxicity data specific to coumaphos. Risk to aquatic non-vascular plants from these exposure pathways is discussed in the Risk Description section of this document.

RQs for listed aquatic vascular plants (**Tables 6-11** and **6-12**) were calculated with the toxicity endpoint of 166 µg/L (*L. gibba*; MRID 43822801). RQs for non-listed aquatic vascular plants were not calculated because the EC_{50} endpoint is non-definitive (*i.e.*, >166 µg/L).

Aquatic vascular plant RQs for runoff are all <0.01. Therefore, the listed aquatic plant LOC of 1 is not exceeded for any runoff exposure pathways.

Aquatic vascular plant RQs for wash-off from one cow entering a 1 acre, 6 foot deep body of water range are all <0.01. Thousands of cows would need to enter a 1 acre, 6 foot deep body of water to cause an LOC exceedance from wash-off for listed aquatic vascular plants.

Table 6-11. Aquatic Vascular Plant Risk Quotients (RQs) for Runoff

PRZM/EXAMS Scenarios	Sources of a.i. from Application Scenario	Wash-Off Fraction	RQs	
			Listed	Non-Listed
Texas: Spray Application (42% flowable concentrate)				
BSSTurf	Runoff from CAFO manure applied to land (No incorporation of manure into soil)	0.02	<0.01	Not calculated
	Runoff from non-regulated small CAFO	0.02	<0.01	
RangeBSS	Runoff from rangeland	0.02	<0.01	
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)				

PRZM/EXAMS Scenarios	Sources of a.i. from Application Scenario	Wash-Off Fraction	RQs	
			Listed	Non-Listed
PA Turf	Runoff from CAFO manure applied to land (No incorporation of manure into soil)	0.027	<0.01	Not calculated
	Runoff from non-regulated small CAFO	0.027	<0.01	
	Runoff from rangeland	0.027	<0.01	

Table 6-12. Aquatic Vascular Plants Risk Quotients (RQs) for Wash-Off from Treated Livestock That Enter Bodies of Water[a]

Maximum Application Rate			Wash-Off Fraction	RQ/cow		Number of Cows to Cause LOC Exceedance	
Type	(lb a.i./ animal)	(mg a.i./ ft^2 cow hide)		Listed	Non-Listed	Listed	Non-Listed
Texas: Dip Vat Application (42% flowable concentrate)							
Single	0.027	272	0.02	<0.01	Not calculated	20750	Not calculated
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)							
Single	0.01	101	0.027	<0.01	Not calculated	41500	Not calculated

[a] 1 acre, 6 foot deep body of water

6.1.2 Direct Effects to Terrestrial Organisms

6.1.2.1 Birds, Reptiles, and Terrestrial-Phase Amphibians

Avian acute RQs were calculated for three exposure pathways resulting from the application of coumaphos to livestock:

- contact with/ingestion of hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas using dose-based EECs for treated cow hides (*i.e.*, 272 and 101 mg a.i./ft^2 cow hide for Texas and the rest of the U.S., respectively) and dietary-based EECs of 370-1228 mg a.i./kg-diet;
- ingestion of coumaphos-contaminated bird carcasses using dose- and dietary-based EECs for coumaphos intake via secondary ingestion (*i.e.*, 1.17×10^{-6}-3.87×10^{-5} mg a.i./g-bw/day and 0.039-0.129 mg/g-diet, respectively);
- ingestion of food items on land receiving manure from CAFOs using EECs from T-REX; and
- ingestion of contaminated fish.

To calculate acute dose-based RQs for the former (primary) exposure pathway, the most sensitive avian acute oral toxicity endpoint (*i.e.*, LD_{50} = 2.4 mg/kg-bw for bobwhite quail; MRID 00112843) was adjusted for the weight of the black-billed magpie (*i.e.*, 186 g; Dunning, 1984), the species most likely to be exposed to coumaphos according to the pilot field study (MRID 42512604), according to the formula provided in **Table 6-13** and compared to the dose-based EECs of 272 and 101 mg a.i./ft^2 cow hide for Texas and the rest of the U.S., respectively. Avian acute dose-based RQs for exposure via contact with/ingestion of hair and skin debris from treated cattle and/or contaminated soil feed in and around treatment areas are 609 and 226 for Texas and the rest of the U.S., respectively (**Table 6-14**). These acute dose-based RQs exceed the avian acute listed and non-listed species LOCs of 0.1 and 0.5, respectively.

Table 6-13. Formula for Calculation of Weight-Adjusted Coumaphos LD_{50} for the Black-Billed Magpie

$$\text{Adjusted } LD_{50(\text{black-billed magpie})}\,(\text{mg/kg-bw}) = \text{Avian } LD_{50}\,(\text{mg/kg-bw}) \left(\frac{SW(g)}{TW(g)}\right)^{x-1}$$

$$= 2.4 \left(\frac{186}{178}\right)$$

$$= 2.4 \text{ mg/kg-bw}$$

Where:

Avian LD_{50} = most sensitive avian acute oral toxicity endpoint (2.4 mg/kg-bw)
SW = body weight of the assessed avian species (186 g black-billed magpie)
TW = body weight of tested avian species (178 g bobwhite quail)
x = Mineau scaling factor for birds (EFED default 1.15)

Table 6-14. Avian Acute Dose-Based Risk Quotient (RQ)[a] for Exposure via Contact with/Ingestion of Hair and Skin Debris from Treated Cattle and/or Contaminated Soil and Feed In and Around Treatment Areas Using EECs for Treated Cow Hides[b]

Dose-Based EEC (mg a.i./ft^2 cow hide)	Adjusted $LD_{50(\text{black-billed magpie})}$ (mg/kg-bw)	Black-Billed Magpie (kg)	Dose-Based RQ[a]
Texas: Dip Vat Application (42% flowable concentrate)			
272[b]	2.4	0.186	**609****
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)			
101b	2.4	0.186	**226****

** exceeds acute listed and non-listed LOCs (=0.5 and 0.1, respectively)

[a] $RQ = \frac{\text{EEC (mg/ft}^2\text{ cow hide)}}{\text{adjusted } LD_{50}\text{ (mg/kg-bw)} * \text{black-billed magpie (kg)}}$

To calculate an acute dietary-based RQ for primary exposure of birds to coumaphos, the most sensitive avian subacute dietary toxicity endpoint (*i.e.*, LC_{50} = 82.1 mg/kg-bw for bobwhite quail; MRID 00112843) was compared to the dietary-based EECs of 370, 853, and 1228 mg/kg-diet to yield avian acute dietary-based RQs of 4.5, 10, and 15, respectively (= [370, 853, or 1228]/82.1). These dietary-based acute RQs for exposure via contact with/ingestion of hair and skin debris from treated cattle and/or contaminated soil/feed in and around treatment areas exceed the avian acute listed and non-listed species LOCs of 0.1 and 0.5, respectively.

To calculate an acute dose-based RQ for secondary exposure of birds to coumaphos, the most sensitive avian acute oral toxicity endpoint (*i.e.*, LD_{50} = 2.4 mg/kg-bw for bobwhite quail; MRID 00112843) was adjusted for the weight of the red-tailed hawk (*i.e.*, 1100 g; USEPA, 1993b), a representative avian predator, according to the formula provided in **Table 6-15** and compared to the dose-based EECs of 1.17×10^{-5}, 2.67×10^{-5}, or 3.87×10^{-5} mg a.i./g-bw/day. Avian acute dose-based RQs for exposure via ingestion of coumaphos-contaminated bird carcasses are 0.012, <0.01, and <0.01 (= [1.17×10^{-5}, 2.67×10^{-5}, or 3.87×10^{-5}]/0.0032). These acute dose-based RQs do not exceed the avian acute listed and non-listed species LOCs of 0.1 and 0.5, respectively.

Table 6-15. Formula for Calculation of Weight-Adjusted Coumaphos LD_{50} for the Red-Tailed Hawk

$$\text{Adjusted } LD_{50(\text{red-tailed hawk})}\ (\text{mg/kg-bw}) = \text{Avian } LD_{50}\ (\text{mg/kg-bw}) \left(\frac{SW(g)}{TW(g)}\right)^{x-1}$$

$$= 2.4\left(\frac{1100}{178}\right)^{1.15-1}$$

= 3.2 mg/kg-bw = 0.0032 mg/g-bw

Where:

Avian LD_{50} = most sensitive avian acute oral toxicity endpoint (2.4 mg/kg-bw)
SW = body weight of the assessed avian species (1100 g red-tailed hawk)
TW = body weight of tested avian species (178 g bobwhite quail)
x = Mineau scaling factor for birds (EFED default 1.15)

To calculate an acute dietary-based RQ for secondary exposure of birds to coumaphos, the most sensitive avian subacute dietary toxicity endpoint (*i.e.*, LC_{50} = 82.1 mg/kg-bw for bobwhite quail; MRID 00112843) was compared to dietary-based EECs of 39, 89, and 129 mg/kg-diet to yield avian acute dietary-based RQs of 0.48, 0.11, and 1.5 (= [39, 89, or 129]/82.1). The latter dietary-based acute RQ for exposure via ingestion of coumaphos-contaminated bird carcasses exceeds the avian acute listed and non-listed species LOCs of 0.1 and 0.5, respectively; the former RQs exceed the listed species LOC of 0.1.

T-REX was used to calculate avian acute RQs for ingestion of food items on land receiving manure from CAFOs (**Table 6-16**). Avian acute RQs range from 0.02 to 4.52. The avian acute non-listed and listed species LOCs of 0.5 and/or 0.1, respectively, are exceeded for small and medium birds.

Table 6-16. Avian Risk Quotients (RQs) for Application of CAFO Manure to Land

Source of Exposure		RQs		
		Small (20 g)	Medium (100 g)	Large (1000 g)
Texas: Spray Application (42% flowable concentrate)				
CAFO manure applied to land	No incorporation into soil	**4.52****	**0.71****	0.05
	Incorporation into soil within a day	**2.71****	**0.43***	0.03
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)				
CAFO manure applied to land	No incorporation into soil	**2.77****	**0.44***	0.03
	Incorporation into soil within a day	**1.54****	**0.24***	0.02

* exceeds avian acute listed species LOC (=0.1)
**exceeds avian acute non-listed species LOC (=0.5)

KABAM was used to calculate acute dose- and dietary-based RQs for ingestion of contaminated fish (**Table 6-17**) using a Km of 0.936/d for fish that was derived from raw data for the fish BCF study. The LOC of 0.1 for listed species of sandpipers and rails is exceeded for wash-off from the skin of 100 cows that enter a body.

Table 6-17. Avian Risk Quotients (RQs) for Birds Consuming Fish Contaminated by Coumaphos

Source of Fish Exposure	PRZM/EXAMS Scenario	Wash-Off Fraction	Wildlife Species	Acute RQs	
				Dose-Based	Dietary-Based
Texas: Spray Application (42% flowable concentrate)					
Runoff from non-regulated small CAFO	BSSTurf	0.02	Sandpipers	0.084	0.002
			Cranes	0.004	0.002
			Rails	0.041	0.002
			Herons	0.005	0.002
			Small osprey	0.004	0.001
			White pelican	0.001	0.000
Wash-off from the skin of 100 cows that enter a body of water	NA	0.02	Sandpipers	**0.268***	0.005
			Cranes	0.013	0.005
			Rails	**0.132***	0.006
			Herons	0.018	0.005
			Small osprey	0.014	0.003
			White pelican	0.003	0.001
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)					
Runoff from non-regulated small CAFO	PA Turf	0.027	Sandpipers	0.097	0.002
			Cranes	0.005	0.002
			Rails	0.048	0.002
			Herons	0.006	0.002
			Small osprey	0.005	0.001
			White pelican	0.001	0.001
Wash-off from the skin of 100 cows that enter a body of water	NA	0.027	Sandpipers	**0.135****	0.003
			Cranes	0.007	0.002
			Rails	0.066	0.003
			Herons	0.009	0.002
			Small osprey	0.007	0.001
			White pelican	0.001	0.001

* exceeds avian acute listed species LOC (=0.1)

Avian chronic RQs were not calculated for any exposure pathways because of the lack of chronic toxicity data specific for coumaphos. Risk to birds from chronic exposure is discussed in the Risk Description section of this document.

6.1.2.2 Mammals

Mammalian RQs were calculated for two exposure pathways resulting from the application of coumaphos to livestock: ingestion of coumaphos-contaminated bird carcasses using dose- and dietary-based EECs for coumaphos intake via secondary ingestion (*i.e.*, 4.16×10^{-6}-1.38×10^{-5} mg a.i./g-bw/day and 0.039-0.129 mg/g-diet, respectively) and ingestion of food items on land receiving manure from CAFOs using EECs in terms of LD_{50}/ft^2 from T-REX.

Acute dietary-based RQs for mammals were not calculated due to the lack of an acute dietary-based toxicity endpoint.

To calculate an acute dose-based RQ for secondary exposure of mammals to coumaphos, the most sensitive mammalian acute oral toxicity endpoint (*i.e.*, LD_{50} = 17 mg/kg-bw for rat; MRID 00110597) was adjusted for the weight of the red fox (*i.e.*, 4500 g; USEPA, 1993b), a representative mammalian predator, according to the formula provided in **Table 6-18** and compared to dose-based EECs of 4.16×10^{-6}, 9.49×10^{-6}, and 1.38×10^{-5} mg a.i./g-bw/day. Mammalian acute dose-based RQs for exposure via ingestion of coumaphos-contaminated bird carcasses are <0.01 (= [4.16×10^{-6}, 9.49×10^{-6}, or 1.38×10^{-5}]/0.025). These acute dose-based RQs do not exceed the mammalian acute listed and non-listed species LOCs of 0.1 and 0.5, respectively.

Table 6-18. Formula for Calculation of Weight-Adjusted Coumaphos LD_{50} and NOAEL for the Red Fox

$\text{Adjusted } LD_{50(\text{red fox})} \text{ (mg/kg-bw)} = \text{Mammalian } LD_{50} \text{ (mg/kg-bw)} \left(\frac{SW(g)}{TW(g)}\right)^{0.25}$
$= 17 \left(\frac{4500}{350}\right)$
= 25 mg/kg-bw = 0.025 mg/g-bw
$\text{Adjusted NOAEL}_{(\text{red fox})} \text{ (mg/kg-bw)} = \text{Mammalian NOAEL (mg/kg-bw)} \left(\frac{SW(g)}{TW(g)}\right)^{0.25}$
$= 1.79 \left(\frac{4500}{350}\right)$
= 2.63 mg/kg-bw = 0.00263 mg/g-bw
Where:
Mammalian LD_{50} or NOAEL = most sensitive mammalian acute oral or chronic toxicity endpoint (17 or 1.79 mg/kg-bw, respectively)
SW = body weight of the assessed avian species (4500 g red fox)
TW = body weight of tested mammalian species (350 g rat)

To calculate a chronic dose-based RQ for secondary exposure of mammals to coumaphos, the most sensitive mammalian chronic toxicity endpoint (*i.e.*, NOAEL = 1.79 mg/kg-bw for rat; MRID 43061701) was adjusted for the weight of the red fox (*i.e.*, 4500 g; USEPA, 1993b), a representative mammalian predator, according to the formula provided in **Table 6-18** and compared to dose-based EECs of 4.16×10^{-6}, 9.49×10^{-6}, and 1.38×10^{-5} mg a.i./g-bw/day. Mammalian chronic dose-based RQs for exposure via ingestion of coumaphos-contaminated bird carcasses are <0.01 (= [4.16×10^{-6}, 9.49×10^{-6}, or 1.38×10^{-5}]/0.00263). These chronic dose-based RQs do not exceed the mammalian chronic listed and non-listed species LOC of 1.

To calculate a chronic dietary-based RQ for secondary exposure of mammals to coumaphos, the most sensitive mammalian chronic toxicity endpoint (*i.e.*, NOAEC = 25 mg/kg-diet for rat; MRID 43061701) was compared to dietary-based EECs of 39, 89, and 129 mg/kg-diet to yield mammalian chronic dietary-based RQs of 1.5, 3.5, and 5.2 (= [39, 89, or 129]/25). These dietary-based chronic RQs for exposure via ingestion of coumaphos-contaminated bird carcasses exceed the mammalian chronic listed and non-listed species LOC of 1.

T-REX was used to calculate mammalian RQs for ingestion of food items on land receiving manure from CAFOs (**Table 6-19**). Mammalian acute RQs range from <0.01 to 0.28. The mammalian acute listed species LOC of 0.1 is exceeded for small and medium mammals.

Table 6-19. Mammalian Risk Quotients (RQs) for Application of CAFO Manure to Land

Source of Exposure		RQs Small (15 g)	RQs Medium (35 g)	RQs Large (1000 g)
Texas: Spray Application (42% flowable concentrate)				
CAFO manure applied to land	No incorporation into soil	**0.28***	**0.15***	0.01
	Incorporation into soil within a day	**0.17***	0.09	0.01
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)				
CAFO manure applied to land	No incorporation into soil	**0.17***	0.09	0.01
	Incorporation into soil within a day	0.09	0.05	<0.01

* exceeds mammalian acute listed species LOC (=0.1)

KABAM was used to calculate dose- and dietary-based RQs for ingestion of contaminated fish (**Table 6-20**) using a Km of 0.936/d for fish that was derived from raw data for the fish BCF study. There are no exceedances for mammals ingesting contaminated fish.

Table 6-20. Mammalian Risk Quotients (RQs) for Mammals Consuming Fish Contaminated by Coumaphos

Source of Fish Exposure	PRZM/ EXAMS Scenario	Wash-Off Fraction	Wildlife Species	Acute Dose-Based RQs	Chronic RQs Dose-Based	Chronic RQs Dietary-Based
Texas: Spray Application (42% flowable concentrate)						
Runoff from non-regulated small CAFO	BSSTurf	0.38	Fog/water shrew	0.003	0.041	0.007
			Rice rat/star-nosed mole	0.003	0.038	0.006
			Small mink	0.001	0.017	0.003
			Large mink	0.001	0.019	0.003
			Small river otter	0.002	0.020	0.003
			Large river otter	0.001	0.012	0.001
Wash-off from the skin of 100 cows that enter a body of water	NA	0.38	Fog/water shrew	0.010	0.132	0.024
			Rice rat/star-nosed mole	0.009	0.122	0.018
			Small mink	0.004	0.055	0.009
			Large mink	0.004	0.061	0.009
			Small river otter	0.005	0.065	0.009
			Large river otter	0.003	0.037	0.005
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)						
Runoff from non-regulated small CAFO	PA Turf	0.116	Fog/water shrew	0.004	0.048	0.009
			Rice rat/star-nosed mole	0.003	0.044	0.007
			Small mink	0.001	0.020	0.003
			Large mink	0.002	0.022	0.003
			Small river otter	0.002	0.024	0.003
			Large river otter	0.001	0.013	0.002
Wash-off from the skin of 100 cows that enter a body of water	NA	0.116	Fog/water shrew	0.005	0.067	0.012
			Rice rat/star-nosed mole	0.005	0.062	0.009
			Small mink	0.002	0.028	0.004
			Large mink	0.002	0.030	0.004
			Small river otter	0.002	0.033	0.004
			Large river otter	0.001	0.019	0.002

6.1.2.3 Terrestrial (Upland and Semi-Aquatic) Plants

RQs for terrestrial (upland and semi-aquatic) plants for exposure via CAFO manure applied to land or runoff from land to which CAFO manure has been applied were not calculated because of the lack of terrestrial plant toxicity data specific to coumaphos. Risk to plants from these two exposure pathways is discussed in the Risk Description section of this document.

6.1.2.4 Honey Bees (In-Hive Use)

RQs for honey bees exposed to coumaphos via impregnated strips placed in hives to control varroa mites and hive beetles were not calculated due to the lack of exposure and/or toxicity data that is suitable for a quantitative approach. Risk to honey bees from exposure to coumaphos is discussed in the Risk Description section of this document.

6.1.3 Probit Slope Dose-Response Analysis of LOC and Acute RQ Values

As part of risk estimation, the Agency provides additional information on the potential for acute direct effects to exposed individuals in terms of the chance of an individual event (*i.e.*, mortality or immobilization) should exposure at the EEC actually occur for a species with sensitivity to coumaphos on par with the acute toxicity endpoint selected for RQ calculation. This is accomplished using the slope of the dose-response relationship available from the toxicity study used to establish the acute toxicity measures of effect for each taxonomic group. The individual effects probability associated with the acute RQ is based on the mean estimate of the slope and an assumption of a probit dose-response relationship. In addition to a single effects probability estimate based on the mean, upper and lower estimates of the effects probability are also provided to account for variance in the slope, if available. Individual effect probabilities are calculated based on an Excel spreadsheet tool IECV1.1 (Individual Effect Chance Model Version 1.1) developed by U.S. EPA, OPP, Environmental Fate and Effects Division (June 22, 2004). The model provides the option of inserting taxa-specific probit slopes and confidence intervals. If specific information is not available, the model uses a default value of 4.5 for the probit slope and 2 and 9 for the upper and lower 95% confidence interval bounds.

Chances of effect (*e.g.*, mortality, immobilization) for an individual organism are provided in **Table 6-21** (fish and aquatic invertebrates) and **Table 6-22** (birds and mammals). For wash-off from treated livestock that enter bodies of water, this analysis was conducted using the RQ or LOC associated with 1 and 100 cows entering a body of water, depending on the taxon. The upper limit of 100 cows was selected based on literature indicating that a 6 foot deep, 1 acre farm pond would be suitable for watering 100 cows (Bray, 2013).

Table 6-21. Chance of Effect (*i.e.*, Mortality or Immobilization) for an Individual Fish or Aquatic Invertebrate at Selected Acute Risk Quotient (RQ) or Level of Concern (LOC)* Values for Coumaphos

Taxon	RQ or LOC*		Probit Slope (95% C.I.)	Chance of Effect 1 in… (95% C.I.)
Freshwater fish	LOC: Runoff	0.05	4.5 (2-9) (default)	4.18x10^{8} (216-1.75x10^{31})
	LOC: Wash-off for 1 cow entering a body of water	0.05		
	LOC: Wash-off for 100 cows entering a body of water	0.05		
Estuarine/ marine fish	LOC: Runoff	0.05	4.5 (2-9) (default)	4.18x10^{8} (216-1.75x10^{31})
	LOC: Wash-off for 1 cow entering a body of water	0.05		
	LOC: Wash-off for 100 cows entering a body of water	0.05		
Freshwater invertebrates	RQ: Runoff from CAFO manure applied to land in Texas	0.68	4.5 (2-9) (default)	4 (3-15)
	RQ: Runoff from CAFO manure applied to land in the rest of the U.S.	0.54		9 (4-125)
	RQ: Runoff from non-regulated small CAFO in Texas	3.4		1 (1-1)
	RQ: Runoff from non-regulated small CAFO in the rest of the U.S.	3.9		1 (1-1)
	RQ: Runoff from rangeland in Texas	0.07		9.88x10^{6} (95-7.58x10^{24})
	LOC: Runoff from rangeland in the rest of the U.S.	0.05		4.18x10^{8} (216-1.75x10^{31})
	RQ: Wash-off for 1 cow entering a body of water in Texas	0.11		1.25x10^{5} (37-3.19x10^{17})
	RQ: Wash-off for 1 cow entering a body of water in the rest of the U.S.	0.05		4.18x10^{8} (216-1.75x10^{31})
	RQ: Wash-off for 100 cows entering a body of water in Texas	11		1 (1-1)
	RQ: Wash-off for 100 cows entering a body of water in the rest of the U.S.	5		1 (1-1)
Estuarine/ marine invertebrates	LOC: Runoff from CAFO manure applied to land	0.05	4.5 (2-9) (default)	4.18x10^{8} (216-1.75x10^{31})
	RQ: Runoff from non-regulated small CAFO in Texas	0.13		2.99x10^{4} (27-1.31x10^{15})
	RQ: Runoff from non-regulated small CAFO in the rest of the U.S.	0.15		9.56x10^{3} (21-1.65x10^{13})
	LOC: Wash-off for 1 cow entering a body of water	0.05		4.18x10^{8} (216-1.75x10^{31})
	LOC: Runoff from rangeland .	0.05		4.18x10^{8} (216-1.75x10^{31})
	RQ: Wash-off for 100 cows entering a body of water in Texas	0.4		28 (5-5.85x10^{3})
	RQ: Wash-off for 100 cows entering a body of water in the rest of the U.S.	0.2		1.21x10^{3} (13-6.33x10^{9})

* listed species LOC (=0.05) was used for analysis when RQ(s) did not exceed listed species LOC

Table 6-22. Chance of Effect (*i.e.*, Mortality) for an Individual Bird or Mammal at Selected Acute Risk Quotient (RQ) or Level of Concern (LOC)* Values for Coumaphos

Taxon	RQ or LOC*		Probit Slope (95% C.I.)	Chance of Effect 1 in... (95% C.I.)
Bird	RQ: Dose-based exposure for primary exposure in Texas RQ: Dose-based exposure for primary exposure in the rest of the U.S.	609 226	4.3 (1.2-7.3) (MRID 00112843)	1 (1-1) 1 (1-1)
	LOC: Dose-based exposure for ingestion of bird carcasses (secondary exposure)	0.1		1.17×10^5 ($9-6.95 \times 10^{12}$)
	RQ: Dose-based exposure for application of CAFO manure to land in Texas (small bird) RQ: Dose-based exposure for application of CAFO manure to land in the rest of the U.S. (small bird)	4.52 2.77		1 (1-1) 1 (1-1)
	RQ: Dietary-based exposure for primary exposure	15	6.6 (3.9-9.7) (MRID 00112843)	1 (1-1)
	RQ: Dietary-based exposure for ingestion of bird carcasses (secondary exposure)	1.5		1 (1-1)
Mammal	LOC: Dose-based exposure for ingestion of bird carcasses (secondary exposure)	0.1	4.5 (2-9) (default)	2.94×10^5 ($44-8.86 \times 10^{18}$)
	RQ: Dose-based exposure for application of CAFO manure to land in Texas (small bird) RQ: Dose-based exposure for application of CAFO manure to land in the rest of the U.S. (small bird)	0.28 0.17		156 ($8-3.07 \times 10^6$) 3.74×10^3 ($17-4.62 \times 10^{11}$)

C.I. = confidence interval
* listed species LOC (=0.1) was used for analysis when RQ did not exceed listed species LOC

6.2 Risk Description

The following risk description explains the overall direct effect conclusions regarding potential ecological risk from the various uses of coumaphos. The risk description takes into consideration all lines of evidence including: risk estimates (*i.e.*, RQ results); information on the chance of individual effect (*i.e.*, mortality or immobilization) for the acute RQ values; comparisons of non-definitive toxicity endpoints (*i.e.*, >) to EECs; data from monitoring, field studies, and reported incidents that may provide additional insights into the likelihood of exposure; and other factors that modify the likelihood of exposure such as timing of application, overlap of area affected and the degree of effect with the presence/absence of taxa, species sensitivity distribution, and presence/absence of dietary items.

6.2.1 Direct Effects to Aquatic Organisms

Risk to aquatic organisms from the following four exposure pathways was estimated:

- uptake from surface waters receiving runoff from land to which contaminated manure has been applied;
- uptake from surface waters receiving runoff from non-regulated small CAFOs (*i.e.*, <300 animals);
- uptake from surface waters receiving runoff from rangeland where treated livestock graze; and
- uptake from surface waters into which treated livestock wade (*i.e.*, wash-off from treated livestock that enter bodies of water).

It should be noted that the possibility of an LOC exceedance for wash-off from treated livestock that enter bodies of water depends on the number of cows involved (*i.e.*, the number of cows that must of wade into 1 acre, 6 foot deep body of water). A 6 foot deep, 1 acre farm pond is suitable for watering 100 cows (Bray, 2013). Therefore, 100 cows was used as a cut-off for determining that there may be a concern for risk from wash-off from treated livestock that enter bodies of water.

6.2.1.1 Fish and Aquatic-Phase Amphibians

For fish, no acute or chronic LOCs (>0.05 and 1, respectively) are exceeded for exposure pathways involving runoff. In addition, hundreds of cows would need to enter a 1 acre, 6 foot deep body of water for there to be LOC exceedances. Probit slope dose-response analyses indicate a small chance of individual mortality (*i.e.*, 1 in 4.18×10^8) for exposure via wash-off from cow entering a body of water and runoff from CAFO manure applied to land, non-regulated small CAFOs, or rangeland. Collectively, these analyses indicate that the potential for risk to freshwater and estuarine/marine fish and aquatic-phase amphibians as a result of the registered uses of coumaphos on livestock is low.

6.2.1.2 Aquatic Invertebrates

Freshwater invertebrates are generally more sensitive to coumaphos than freshwater invertebrates, and there are more exceedances for freshwater invertebrates compared to their estuarine/marine counterparts.

For freshwater invertebrates in Texas and the rest of the U.S., acute and chronic LOCs for listed and non-listed species (>0.5 and 1, respectively) are exceeded for runoff from unincorporated CAFO manure applied to land and runoff from non-regulated small CAFOs. For runoff from rangeland, only the acute listed species LOC (0.05) is exceeded for Texas. Furthermore, only one to ten cows would have to enter a 1 acre, 6 foot deep body of water for there to be acute and chronic LOC exceedances for listed and non-listed species of freshwater invertebrates. Probit slope dose-response analyses for the exposure pathways yielding the highest RQs – runoff from non-regulated small CAFOS and wash-off from 100 cows entering a body of water – indicate a high chance of individual mortality (*i.e.*, 1 in 1) for freshwater invertebrates.

For estuarine/marine invertebrates, the only exceedances for pathways involving runoff are for exposure via runoff from non-regulated small CAFOs for listed species. For wash-off from treated cows that enter bodies of water (*i.e.*, 1 acre, 6 foot deep body of water), there are exceedances for acute exposure of listed species and chronic exposure of listed and non-listed species for 13 to 86 cows. Probit slope dose-response analyses for the exposure pathways yielding the highest RQs – runoff from non-regulated small CAFOS and wash-off from 100 cows entering a body of water – indicate a 1 in 9560 to 29,900 and 1 in 18 to 1210 chance of individual mortality, respectively.

The potential for risk to benthic invertebrates was evaluated via the use of pore water EECs and toxicity data for freshwater invertebrates closely parallels that of the potential for risk to freshwater invertebrates. However, there is some uncertainty associated with this conclusion since the toxicity endpoints used to calculate RQs were generated from studies in which exposure occurred via the water column instead of via sediment.

Collectively, these analyses imply that freshwater, estuarine/marine, and benthic invertebrates may be adversely affected by the registered use of coumaphos on livestock. This conclusion is not unexpected given the conclusions of previous assessments (see **Section 2.2**) as well as toxicity data indicating that invertebrates are exquisitely sensitive to coumaphos, which targets invertebrates.

6.2.1.3 Aquatic Plants

For aquatic vascular plants, the listed species LOC (1) is not exceeded for runoff, regardless of the source of exposure, suggesting that concern for risk to listed species from exposure via this pathway is low. RQs for non-listed aquatic vascular plants were not calculated because the EC_{50} endpoint is non-definitive (*i.e.*, >166 µg/L). However, the EC_{50} for aquatic vascular plants must be greater than the NOAEC of 166 µg a.i./L. Since there is no LOC exceedance using the NOAEC, concern for risk to non-listed aquatic vascular plants from exposure to coumaphos via runoff is also presumed low. The estimation of risk to aquatic vascular plants from exposure via wash-off from treated livestock that enter bodies of water indicates that over 1000 cows would have to wade into 1 acre, 6 foot deep body of water for there to be a concern for risk to aquatic vascular plants from exposure via this pathway which is unlikely. Collectively, these analyses imply that the concern for risk to aquatic vascular plants from the registered use of coumaphos on livestock is low.

RQs for aquatic non-vascular plants for exposure via runoff and wash-off were not calculated because of the lack of toxicity data specific to coumaphos. Instead, the most sensitive aquatic non-vascular plant toxicity endpoints for a surrogate organophosphate insecticide were compared to peak EECs for runoff and wash-off (**Tables 6-23** and **6-24**). Aquatic non-vascular plant toxicity data are available for the several organophosphate insecticides including chlorpyrifos, diazinon, dichlorvos, dicrotophos, dimethoate, EPN, fenthion, naled, oxydemeton-methyl, phorate, and trichlorfon. Of the available data, naled is the most toxic to aquatic non-vascular plants. The most sensitive endpoints for naled are those for *N. pelliculosa*: EC_{50} = 24 µg a.i./L and NOAEC = 4.2 µg a.i./L. For runoff, peak EECs do not exceed the toxicity endpoints for any of the scenarios. For wash-off from the skin of treated livestock that enter bodies of water, hundreds of cows would need to wade into 1 acre, 6 foot deep body of water for the EECs to be greater than the endpoints for naled. Collectively, these analyses indicate that the potential for risk to aquatic non-vascular plants as a result of the registered uses of coumaphos on livestock is low. However, there is uncertainty associated with this risk conclusion given that aquatic non-vascular plants may be more or less sensitive to coumaphos than to naled.

Table 6-23. Comparison of Aquatic Non-Vascular Toxicity Endpoints for Naled to Runoff Estimated Environmental Concentrations (EECs) for Coumaphos + Coumaphoxon

PRZM/ EXAMS Scenarios	Sources of a.i. from Application Scenario	Wash-Off Fraction	Peak EEC (µg/L)	Naled EC_{50} (µg/L)	Naled NOAEC (µg/L)	Peak EEC > EC_{50}?	Peak EEC > NOAEC?
Texas: Spray Application (42% flowable concentrate)							
BSSTurf	Runoff from CAFO manure applied to land (no incorporation)	0.02	0.05	24	4.2	No	No
	Runoff from CAFO manure applied to land (incorporation)	0.02	0.0031				
	Runoff from non-regulated small CAFO	0.02	0.25				
RangeBSS	Runoff from rangeland	0.02	0.005				
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)							
PA Turf	Runoff from CAFO manure applied to land (no incorporation)	0.027	0.04	24	4.2	No	No
	Runoff from CAFO manure applied to land (incorporation)	0.027	0.0022				
	Runoff from non-regulated small CAFO	0.027	0.29				
	Runoff from rangeland	0.027	0.0013				

Table 6-24. Comparison of Aquatic Non-Vascular Toxicity Endpoints for Naled to Estimated Environmental Concentrations (EECs) for Coumaphos + Coumaphoxon for Wash-Off from the Skin of Treated Livestock That Enter Bodies of Water

Maximum Application Rate			Wash-Off Fraction	Peak EEC (EEC/cow) (µg/L)	Naled EC_{50} (µg/L)	Naled NOAEC (µg/L)	Number of Cows Needed to Exceed Toxicity Endpoint[b]	
Type	(lb a.i./ animal)	(mg a.i./ ft^2 cow hide)					Non-listed	Listed
Texas: Spray Application (42% flowable concentrate)								
Single	0.027	274	0.02	0.008	24	4.2	3000	525
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)								
Single	0.01	101	0.02	0.004	24	4.2	6000	1050

[a] 1 acre, 6 foot deep body of water
[b] Toxicity endpoint/peak EEC

6.2.2 Direct Effects to Terrestrial Organisms

6.2.2.1 Birds, Reptiles, and Terrestrial-Phase Amphibians

Risk to birds from the following four exposure pathways was estimated:

- contact with/ingestion of hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas (primary exposure);
- ingestion of contaminated bird carcasses (secondary exposure);
- ingestion of food items on land receiving manure from CAFOs; and
- ingestion of contaminated fish.

For primary exposure, avian acute dose- and dietary-based RQs of 226 to 609 and 4.5 to 15, respectively, exceed avian acute listed and non-listed species LOCs (0.1 and 0.5, respectively). These RQs for avian primary exposure correspond to a 1 in 1 chance of individual mortality. For secondary exposure via the consumption of contaminated bird carcasses, none of the avian acute dose-based RQs exceed acute LOCs. However, the avian acute dietary-based RQs of 0.48 to 1.5 exceed avian acute non-listed and/or listed species LOCs. The highest RQ for avian secondary exposure corresponds to a high chance of individual mortality (*i.e.*, 1 in 1). For ingestion of food items on land receiving manure from CAFOs, RQs for small and medium birds exceed the avian acute non-listed and/or listed species LOCs, and the highest RQs (*i.e.*, those for small mammals) correspond to a 1 in 1 chance of individual mortality. For ingestion of contaminated fish, acute RQs exceed the listed species LOC for only sandpipers and rails.

Avian chronic RQs were not calculated due to the lack of chronic toxicity data for coumaphos. Instead, the most sensitive avian chronic toxicity endpoint for a surrogate organophosphate insecticide was compared directly to EECs for the three of the four exposure pathways (**Table 6-25**). Comparisons were not made for exposure via CAFO manure applied to land because only acute EECs (in terms of LD_{50}/ft^2) can be modeled for broadcast application of granules in T-REX. Avian chronic, reproductive toxicity data are available for the following phosphorothioates: fenitrothion, parathion, and methyl parathion. Of the available data, parathion is the most toxic to birds on a chronic basis. The most sensitive endpoint for parathion is that for mallard duck: NOAEC = 2.85 mg/kg-diet. EECs are greater than parathion's chronic toxicity endpoint for exposure via hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas indicating that birds may be at risk from chronic exposure via this pathway. In contrast, dietary-based EECs for secondary exposure via ingestion of contaminated bird carcasses and fish contaminated via runoff or wash-off are less than the estimated chronic toxicity endpoint suggesting the concern for risk to birds via these pathways is low. However, there is uncertainty associated with these risk conclusions for chronic exposure given that birds may be more or less sensitive to coumaphos than to parathion on a chronic basis. It should be noted that previous assessments including the 1996 RED did not assess risk to birds from chronic exposure with the rationale being that significant acute exposure of birds to coumaphos would likely result in mortality before chronic effects could occur (USEPA, 1996).

Table 6-25. Comparison of an Avian Chronic Toxicity Endpoint for Parathion to Estimated Environmental Concentrations (EECs) for Coumaphos

Source of Exposure	Wildlife Species	EEC (mg/kg-diet)	Parathion Chronic Toxicity Endpoint (mg/kg-diet)	EEC > Toxicity Endpoint?
Hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas	NA	1228	2.85	**Yes**
		853		
		370		
Contaminated bird carcasses (secondary exposure)	NA	0.039	2.85	No
		0.089		
		0.129		
Texas: Fish contaminated via runoff	Sandpipers	0.14	2.85	No
	Cranes	0.13		
	Rails	0.15		
	Herons	0.13		
	Small osprey	0.07		
	White pelican	0.04		
Texas: Fish contaminated via wash-off	Sandpipers	0.45	2.85	No
	Cranes	0.40		
	Rails	0.48		
	Herons	0.41		
	Small osprey	0.22		
	White pelican	0.12		
Rest of the U.S.: Fish contaminated via runoff	Sandpipers	0.16	2.85	No
	Cranes	0.14		
	Rails	0.17		
	Herons	0.15		
	Small osprey	0.08		
	White pelican	0.04		
Rest of the U.S.: Fish contaminated via wash-off	Sandpipers	0.23	2.85	No
	Cranes	0.20		
	Rails	0.24		
	Herons	0.20		
	Small osprey	0.11		
	White pelican	0.06		

NA = not applicable

Collectively, these analyses imply that birds may be at risk from acute exposure via multiple pathways as a result of the registered use of coumaphos on livestock. This concern for risk to birds is supported by documented incidents involving birds and coumaphos (see **Section 5.3**) and the conclusion of previous assessments (see **Section 2.2**).

It should be noted that the conclusions for risk from primary exposure via contact with/ingestion of hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas and secondary exposure via ingestion of contaminated bird carcasses are based on EECs calculated using several conservative assumptions (see **Section 4.3.1.2**) and mean residues of coumaphos detected in bovine hair (a surrogate for potential contaminated food items) 1, 24, and 72 hours post-treatment as reported in the pilot field study (MRID 42512604).

In addition, there are several uncertainties associated with risk estimates from exposure via ingestion of contaminated fish including the following:

- EECs for this pathway were determined using surface water and pore water EECs which were calculated using conservative assumptions described in **Section 4.2**.
- In the absence of data, the metabolic rate constant for lower trophic levels was assumed to be zero. Metabolism of coumaphos by lower trophic levels would result in lower EECs and thus decreased estimates of risk (*i.e.*, lower RQs).

6.2.2.2 Mammals

Risk to mammals from the following three exposure pathways was estimated:

- ingestion of contaminated bird carcasses (secondary exposure);
- ingestion of food items on land receiving manure from CAFOs; and
- ingestion of contaminated fish.

For secondary exposure via ingestion of contaminated bird carcasses, mammalian acute dose-based RQs (<0.01) do not exceed mammalian acute listed and non-listed species LOCs (0.1 and 0.5, respectively), and a probit dose-response analysis using the listed species LOC of 0.1 indicates a relatively low chance of individual mortality (*i.e.*, 1 in 2.94×10^5). In addition, mammalian chronic dose-based RQs (<0.01) for secondary exposure do not exceed the mammalian chronic LOC of 1. However, mammalian chronic dietary-based RQs (1.5-3.2) for secondary exposure do exceed the mammalian chronic LOC. For exposure via ingestion of food items on land receiving manure from CAFOs, acute RQs exceed the mammalian acute LOC (0.1) for listed species, and the highest RQs (*i.e.*, those for small mammals) correspond to a 1 in 156 to 1 in 3.74×10^4 chance of individual mortality. For exposure via ingestion of contaminated fish, there are no exceedances of LOCs. Collectively, these analyses imply that mammals may be at risk from chronic exposure via ingestion of contaminated bird carcasses (secondary exposure) and acute exposure via ingestion of food items on land receiving manure from CAFOs as a result of the registered use of coumaphos on livestock. It should be noted that this conclusion contrasts with that of previous assessments because those assessments did not assess risk to mammals via contaminated bird carcasses or application of CAFO manure to land.

Furthermore, it should be noted that the conclusions for risk from secondary exposure via ingestion of contaminated bird carcasses were based on EECs calculated using several conservative assumptions (see **Section 4.3.1.2**) and mean residues of coumaphos detected in bovine hair (a surrogate for potential contaminated food items) 1, 24, and 72 hours post-treatment as reported in the pilot field study (MRID 42512604).

6.2.2.3 Terrestrial (Upland and Semi-Aquatic) Plants

RQs for terrestrial (upland and semi-aquatic) plants for exposure via CAFO manure applied to land or runoff from land to which CAFO manure has been applied were not calculated because of the lack of terrestrial plant toxicity data specific to coumaphos. Instead, the most sensitive terrestrial plant endpoints for a surrogate organophosphate insecticide were compared to direct application and runoff EECs for CAFO manure (**Table 6-26**). Terrestrial plant toxicity data are available for the several organophosphate insecticides including diazinon, disulfoton, fosthiazate, isofenfos, and profenofos. Of the available data, profenofos is the most toxic to terrestrial plants. None of the EECs are greater than the toxicity endpoints for profenofos. This analysis indicates that the potential for risk to terrestrial (upland and semi-aquatic) plants as a result of the registered uses of coumaphos on livestock is low. However, there is uncertainty associated with this risk conclusion given that terrestrial plants may be more or less sensitive to coumaphos.

Table 6-26. Comparison of Terrestrial Plant Toxicity Endpoints for Profenofos to Estimated Environmental Concentrations (EECs) for Coumaphos

Source of Exposure		Direct Application EEC (lb a.i./A)	Runoff EEC (lb a.i./A)		Seedling Emergence (lb a.i./A)				Vegetative Vigor (lb a.i./A)				EEC > Toxicity Endpoint?
		All Areas	Dry (Upland) Areas	Semi-Aquatic Areas	Monocot		Dicot		Monocot		Dicot		
					EC_{25}	NOAEC	EC_{25}	NOAEC	EC_{25}	NOAEC	EC_{25}	NOAEC	
Texas: Spray Application (42% flowable concentrate)													
CAFO manure applied to land	No incorporation into soil	0.015	0.0003	0.003	>1	1	0.13	0.111	NA	1	NA	1	No
	Incorporation into soil within a day		0.00018	0.0018									No
Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)													
CAFO manure applied to land	No incorporation into soil	0.0092	0.000184	0.00184	>1	1	0.13	0.111	NA	1	NA	1	No
	Incorporation into soil within a day		0.000102	0.00102									No

NA = not applicable

6.2.2.4 Honey Bees (In-Hive Use)

RQs for honey bees exposed to coumaphos via impregnated strips placed in hives to control varroa mites and hive beetles were not calculated due to the lack of exposure and/or toxicity data that is suitable for a quantitative approach. Instead, EECs in the form of open literature data on coumaphos residues (mg/kg) detected in bees and queen cells from hives treated with coumaphos-impregnated strips during controlled experiments (E066848) were compared to open literature data on the toxicity of coumaphos to bees (**Table 6-27**). The NOAEC for exposure via queen cups (10 mg/kg) exceeds the lowest queen cell EEC (8.11 mg/kg), and the LOAEC for exposure via queen cups (100 mg/kg) is within the range of queen cell EECs (8.11-237 mg/kg). In addition, the lowest LD_{50}'s (23.4, 24.2 mg/kg) are almost equal to the highest concentration of coumaphos detected in bees (23.26 mg/kg). This qualitative assessment indicates that there may be a concern for risk to honey bees from the registered in-hive use of coumaphos. It should be noted that the range of coumaphos EECs reported as part of a broad survey of pesticide residues in commercial bee hives in North America (MRID 49497801) generally confirm concentrations measured during the controlled experiment in which hives were treated with coumaphos-impregnated strips.

Table 6-27. Comparison of A) Estimated Environmental Concentrations (EECs) of Coumaphos and B) Coumaphos Toxicity Data for Honey Bees

A) EECs		
Sample Type	**Conc. (mg/kg)**	**Source & Classification**
Queen cells	8.11-237[a]	E066848 Qualitative
Wax	12.69-120[a] 0.001-91.9[b]	E066848 Qualitative MRID 49497801
Bees	0.83-23.26[a] 0.001-0.762[b]	E066848 Qualitative MRID 49497801
Pollen	0.001-5.828[b]	MRID 49497801
B) Toxicity Data		
Route of Exposure	**Endpoint (mg/kg)**	**Source & Classification**
Queen cups	10-day NOAEC = 10 10-day LOAEC = 100	E100910 Quantitative E100380 Quantitative
Contact	24-hr LD_{50} = 159.3[c]	E119503 Qualitative
Oral	8 day old bees: 48-hr LD_{50} = 23.4[c] 14 day old bees: 48-hr LD_{50} = 24.2[c] 3 day old bees: 48-hr LD_{50} = 47.19[c]	E101175 Quantitative

[a] from hives treated with coumaphos-impregnated strips
[b] whether or not the samples were from hives that were treated with coumaphos is not known
[a] (LD_{50} (µg/bee) / 128 µg/bee)*1000

6.3 Summary of Direct Effects

A summary of the direct effects of coumaphos to aquatic and terrestrial organisms is provided in **Tables 6-28** and **6-29**.

Table 6-28. Summary of Direct Effects for Aquatic Organisms

Taxon	Status	Concern for risk from direct effects?*	Basis for Conclusion: RQ exceedance (type: acute and/or chronic)? Exposure pathways: Runoff from land to which CAFO manure has been applied	Runoff from non-regulated small CAFOs (*i.e.*, < 300 animals)	Runoff from rangeland	Wash-off from treated livestock that enter bodies of water	Incidents?	Comments
Freshwater fish and aquatic-phase amphibians	Listed	No	No	No	No	No	No	--
	Non-Listed	No	No	No	No	No		
Estuarine/marine fish	Listed	No	No	No	No	No	No	--
	Non-Listed	No	No	No	No	No		
Freshwater invertebrates	Listed	Yes	Texas, Rest of U.S.: Yes (acute & chronic)	Texas, Rest of U.S.: Yes (acute & chronic)	Texas: Yes (acute) Rest of U.S.: No	Texas, Rest of U.S.: Yes (acute & chronic)	No	--
	Non-Listed	Yes	Texas, Rest of U.S.: Yes (acute & chronic)	Texas, Rest of U.S.: Yes (acute & chronic)	No	Texas, Rest of U.S.: Yes (acute & chronic)		
Estuarine/marine invertebrates	Listed	Yes	No	Texas, Rest of U.S.: Yes (acute)	No	Texas, Rest of U.S.: Yes (acute & chronic)	No	Exposure via wash-off may not be a complete exposure pathway given that the likelihood of livestock entering estuarine/marine bodies of water is uncertain
	Non-Listed	Yes	No	No	No	Texas, Rest of U.S.: Yes (chronic)		
Benthic (sediment-dwelling) invertebrates	Listed	Yes	RQs not calculated	Texas, Rest of U.S.: Yes (acute & chronic)	RQs not calculated	Texas, Rest of U.S.: Yes (acute & chronic)	No	RQs were calculated using pore water EECs and toxicity endpoints from water column exposure studies with freshwater invertebrates.
	Non-Listed	Yes		Texas, Rest of U.S.: Yes (acute & chronic)		Texas, Rest of U.S.: Yes (acute & chronic)		
Aquatic vascular plants	Listed	No	No	No	No	No	No	--
	Non-Listed	No	No	No	No	No		

Taxon	Status	Concern for risk from direct effects?*	Basis for Conclusion					
			RQ exceedance (type: acute and/or chronic)?				Incidents?	Comments
			Exposure pathways:					
			Runoff from land to which CAFO manure has been applied	Runoff from non-regulated small CAFOs (*i.e.*, < 300 animals)	Runoff from rangeland	Wash-off from treated livestock that enter bodies of water		
Aquatic non-vascular plants	Listed	NA	RQs not calculated				No	There is uncertainty associated with the risk conclusion as it is based on a qualitative analysis using toxicity data for a surrogate organophosphate insecticide.
	Non-Listed	No						

NA = not applicable; no listed aquatic non-vascular plants

* Direct or indirect effects to specific listed species have not been definitively determined; further investigation into temporal, geographical, and biological associations between the registered uses and affected taxa is needed before definitive effects determinations can be made.

Table 6-29. Summary of Direct Effects for Terrestrial Organisms

Taxon	Status	Concern for risk from direct effects?*	Basis for Conclusion						
			RQ exceedance (type: acute and/or chronic)?					Incidents?	Comments
			Exposure pathways:						
			Hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas	Contaminated bird carcasses	CAFO manure applied to land	Runoff from land to which CAFO manure has been applied	Contaminated fish		
Birds, reptiles, and terrestrial-phase amphibians	Listed	Yes	Texas, Rest of U.S.: Yes (acute)	Texas, Rest of U.S.: Yes (acute)	Texas, Rest of U.S.: Yes (acute)	NA	Texas, Rest of U.S.: Yes (acute; select species)	Yes	RQs were not calculated for chronic exposure due to the lack of avian chronic toxicity data. However, a comparison of EECs with an avian chronic toxicity endpoint for a surrogate organophosphate insecticide indicates that there may be a concern for risk from direct effects for exposure via: □ hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas; and □ contaminated fish. There is uncertainty associated with these risk conclusions for chronic exposure given the use of a toxicity endpoint for a surrogate organophosphate insecticide.
	Non-Listed	Yes	Texas, Rest of U.S.: Yes (acute)	Texas, Rest of U.S.: Yes (acute)	Texas, Rest of U.S.: Yes (acute)		No		
Mammals	Listed	Yes	NA	Texas, Rest of U.S.: Yes (chronic)	Texas, Rest of U.S.: Yes (acute)	NA	No	No	--
	Non-Listed	Yes		Texas, Rest of U.S.: Yes (chronic)	No		No		
Terrestrial (upland and	Listed	No	RQs not calculated					No	There is uncertainty associated with the risk conclusions as they are based on a qualitative analysis using

Taxon	Status	Concern for risk from direct effects?*	Basis for Conclusion						
			RQ exceedance (type: acute and/or chronic)?					Incidents?	Comments
			Exposure pathways:						
			Hair and skin debris from treated cattle and/or contaminated soil and feed in and around treatment areas	Contaminated bird carcasses	CAFO manure applied to land	Runoff from land to which CAFO manure has been applied	Contaminated fish		
semi-aquatic) plants	Non-Listed	No							toxicity data for surrogate organophosphate insecticide.
Honey bees (in-hive use)	Listed	NA**	NA					Yes	The risk conclusion is based on a qualitative analysis.
	Non-Listed	Yes							

NA = not applicable
* * Direct or indirect effects to specific listed species have not been definitively determined; further investigation into temporal, geographical, and biological associations between the registered uses and affected taxa is needed before definitive effects determinations can be made.
** Not applicable because the analysis for in-hive use only applies to honey bees which are non-listed.

6.4 Listed Species Effects Determinations

Based on this screening-level assessment, there are potential risks of direct effects to listed aquatic invertebrates, birds, and mammals from the use of coumpahos on some of its registered use sites. Listed species of all taxa may also be affected through indirect effects because of the potential direct effects on listed and non-listed species. Potential direct effects on listed fish, aquatic invertebrates, birds, and mammals from the use coumaphos may be associated with modification of Primary Constituent Elements (PCEs) of designated critical habitats, where such designations have been made. However, at this current stage of the Registration Review process, it is premature to make effects determinations for listed species until further scientific analysis and refinements are conducted, based on recommendations received from the National Academy of Sciences' (NAS) National Research Council (NRC) April 2013 report, available at http://www.nap.edu/catalog.php?record_id=18344. The NAS report outlines recommendations on specific scientific and technical issues related to the development of pesticide risk assessments that are compliant with the Endangered Species Act (ESA) and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

The EPA along with the U.S. Fish & Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS) (collectively, the Services), and the U.S. Department of Agriculture (USDA), released a summary of their implementation plan for assessing risks of pesticides to listed species ahead of the stakeholder workshop held on November 15, 2013. This plan was developed in response to the NAS' recommendations, including a common approach to risk assessment as a way of addressing scientific differences between EPA and the Services. During the workshop, the agencies received feedback from the public on the interim scientific approaches that were developed as part of the initial implementation of the NAS recommendations. These approaches will be jointly implemented and vetted as part of a phased iterative process. Once fully vetted, EPA will further refine the listed species effects determination portion of this risk assessment.

To make effects determinations for individual listed species, useful refinements may include, but are not limited to, analyses of: 1) more detailed, species-specific ecological and biological data; 2) more detailed and accurate information on coumaphos use patterns; and 3) sub-county level spatial proximity data for the co-occurrence of potential effects areas and listed species and any designated critical habitat. Examples of such refinements are described below.

EFED is currently developing tools that are expected to further refine the assessment and are designed to support effects determinations for individual federally listed species and their designated critical habitats (where applicable). Scientific information obtained from the Services, and other reliable sources is being collated by EFED to address all currently listed species. This information is being stored in an Office of Pesticide Programs (OPP) Pesticide Registration Information SysteM (PRISM) listed species knowledgebase. The listed species knowledgebase consists of an information repository that houses biological and behavioral information relevant to individual species (*e.g.*, habitat, diet, and life history, including specific temporal and spatial associations) and a document repository that contains supporting documents (*e.g.*, USFWS recovery plans) and electronic information (*e.g.*, GIS data files). For terrestrial taxa, biological information relevant to the assessment (*e.g.*, diet and body weight) will be used to parameterize exposure estimates using a method consistent with currently used methods in the T-REX and T-HERPS models.

Refinements will also include more detailed analyses of the registered uses and specific use patterns that result in either "Likely to Adversely Affect" (LAA) or "Not Likely to Adversely Affect" (NLAA) determinations for federally listed species. The analyses may include more information on where, when, and how coumaphos is used on all use sites. Actual usage data (when available) and national land-cover datasets that indicate potential use sites [*e.g.*, National Land Cover Dataset (NLCD), Cropland Data Layer (CDL)] may be used to support a more refined analysis of where coumaphos is reasonably expected to be used. Similarly, refinements on the timing of applications and a more in-depth exploration of agronomic practices for coumaphos may be included as part of the refinement.

The refinements based on individual species data; additional, detailed usage information, when available; and recommendations from the NRC report are expected to help to more accurately identify potential areas of effect and to better inform effects and habitat determinations for listed species and any designated critical habitats.

7 Uncertainties

A description of basic assumptions, uncertainties, strengths, and limitations of a typical risk assessment is described in Chapter 6 of the Agency's Overview Document (USEPA, 2004) and includes those related to exposure for all taxa, those related to exposure for aquatic species, those related to exposure for terrestrial animals, those related to the effects assessment, and those associated with the acute LOC values. Additional uncertainties for this assessment are discussed below.

7.1 Estimates of Exposure

In this risk assessment, EFED attempted to locate the best available data/models for estimating coumaphos residues in food items of non-target organisms, CAFO manure that applied to land, and potential runoff from CAFOs and rangeland. Frequently, such information is better expressed as ranges rather than points, and when this is the case, EFED typically opts to use the end of range which would result in the highest estimate of risk in order to ensure protection of ecological receptors and their habitats. However, EFED used wash-off fractions for the 24-hour drying time in this assessment because they represent a reasonable time frame after application for a treated cow to be caught in a rainstorm or enter a body of water. Potential exposure could be higher or lower depending on CAFO operations such as an indoor or outdoor facility, numbers of cattle treated/day, and many other variables associated with manure managements for crop productions as well as weather conditions. Uncertainty associated with each of these individual components could potentially dictate higher or lower EECs.

7.2 Endocrine Disruptor Screening Program (EDSP)

As required under FFDCA section 408(p), EPA has developed the Endocrine Disruptor Screening Program (EDSP) to determine whether certain substances (including pesticide active and other ingredients) may have an effect in humans or wildlife similar to an effect produced by a "naturally occurring estrogen, or other such endocrine effects as the Administrator may designate." The EDSP employs a two-tiered approach to making the statutorily required determinations. Tier 1 consists of a battery of 11 screening assays to identify the potential of a chemical substance to interact with the estrogen, androgen, and or thyroid (E, A, or T) hormonal systems. Chemicals that go through Tier 1 screening and are found to have the potential to interact with E, A, or T hormonal systems will proceed to the next stage of the EDSP where EPA will determine which, if any, of the Tier 2 tests are necessary based on the available data. Tier 2 testing is designed to identify any adverse endocrine related effects caused by the substance, and establish a dose-response relationship between the dose and the E, A, or T effect.

Between October 2009 and February 2010, EPA issued test orders/data call-ins for the first group of 67 chemicals, which contains 58 pesticide active ingredients and 9 inert ingredients. This list of chemicals was selected based on the potential for human exposure through pathways such as food and water, residential activity, and certain post-application agricultural scenarios. This list should not be construed as a list of known or likely endocrine disruptors.

Coumaphos was not among the group of 58 pesticide active ingredients that received EDSP test orders. Additional information on the EDSP, including the policies and procedures, the list of 67 chemicals, the test guidelines and the Tier 1 screening battery, can be found at http://www.epa.gov/scipoly/oscpendo/index.htm.

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Appendix A: Example PRZM/EXAMS Output

Water Column

stored as TX R_02_E.out

Chemical: Coumaphos

PRZM environment: TurfBSS.txt, modified Wedday, 31 July 2013 at 14:00:27

EXAMS environment: pond298.exv, modified Tueday, 26 August 2008 at 06:14:08

Metfile: w13958.dvf, modified Tueday, 26 August 2008 at 06:14:44

Water segment concentrations (ppb)

Year	Peak	96 hr	21 Day	60 Day	90 Day	Yearly
1961	0.06	0.05	0.03	0.02	0.02	0.01
1962	0.11	0.09	0.06	0.04	0.04	0.02
1963	0.07	0.07	0.05	0.04	0.04	0.03
1964	0.21	0.18	0.11	0.08	0.07	0.05
1965	0.18	0.16	0.12	0.11	0.10	0.09
1966	0.14	0.13	0.11	0.10	0.10	0.09
1967	0.13	0.12	0.11	0.10	0.10	0.09
1968	0.13	0.12	0.11	0.10	0.10	0.10
1969	0.13	0.12	0.11	0.10	0.10	0.10
1970	0.19	0.17	0.14	0.12	0.11	0.10
1971	0.11	0.11	0.10	0.10	0.10	0.10
1972	0.15	0.13	0.11	0.10	0.10	0.09
1973	0.24	0.22	0.18	0.15	0.13	0.10
1974	0.23	0.20	0.16	0.13	0.13	0.12
1975	0.24	0.22	0.18	0.15	0.15	0.14
1976	0.21	0.20	0.17	0.15	0.15	0.14
1977	0.16	0.15	0.14	0.14	0.13	0.13
1978	0.19	0.18	0.15	0.13	0.13	0.12
1979	0.33	0.29	0.22	0.18	0.18	0.15
1980	0.19	0.19	0.17	0.16	0.16	0.15
1981	0.45	0.40	0.30	0.24	0.22	0.18
1982	0.25	0.24	0.21	0.20	0.20	0.19
1983	0.19	0.18	0.18	0.18	0.18	0.17
1984	0.17	0.16	0.16	0.16	0.16	0.15
1985	0.19	0.18	0.16	0.15	0.15	0.15
1986	0.23	0.22	0.18	0.16	0.16	0.14
1987	0.24	0.22	0.20	0.17	0.17	0.15
1988	0.16	0.16	0.15	0.15	0.15	0.14
1989	0.15	0.15	0.14	0.13	0.13	0.13
1990	0.17	0.16	0.14	0.13	0.13	0.12

Sorted results

Prob.	Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.03	0.45	0.40	0.30	0.24	0.22	0.19

0.06	0.33	0.29	0.22	0.20	0.20	0.18
0.10	0.25	0.24	0.21	0.18	0.18	0.17
0.13	0.24	0.22	0.20	0.18	0.18	0.15
0.16	0.24	0.22	0.18	0.17	0.17	0.15
0.19	0.24	0.22	0.18	0.16	0.16	0.15
0.23	0.23	0.22	0.18	0.16	0.16	0.15
0.26	0.23	0.20	0.18	0.16	0.16	0.15
0.29	0.21	0.20	0.17	0.15	0.15	0.14
0.32	0.21	0.19	0.17	0.15	0.15	0.14
0.35	0.19	0.18	0.16	0.15	0.15	0.14
0.39	0.19	0.18	0.16	0.15	0.15	0.14
0.42	0.19	0.18	0.16	0.15	0.13	0.13
0.45	0.19	0.18	0.15	0.14	0.13	0.13
0.48	0.19	0.17	0.15	0.13	0.13	0.12
0.52	0.18	0.16	0.14	0.13	0.13	0.12
0.55	0.17	0.16	0.14	0.13	0.13	0.12
0.58	0.17	0.16	0.14	0.13	0.13	0.10
0.61	0.16	0.16	0.14	0.12	0.11	0.10
0.65	0.16	0.15	0.12	0.11	0.10	0.10
0.68	0.15	0.15	0.11	0.10	0.10	0.10
0.71	0.15	0.13	0.11	0.10	0.10	0.10
0.74	0.14	0.13	0.11	0.10	0.10	0.09
0.77	0.13	0.12	0.11	0.10	0.10	0.09
0.81	0.13	0.12	0.11	0.10	0.10	0.09
0.84	0.13	0.12	0.11	0.10	0.10	0.09
0.87	0.11	0.11	0.10	0.08	0.07	0.05
0.90	0.11	0.09	0.06	0.04	0.04	0.03
0.94	0.07	0.07	0.05	0.04	0.04	0.02
0.97	0.06	0.05	0.03	0.02	0.02	0.01
0.10	0.25	0.24	0.21	0.18	0.18	0.17
			Average of yearly averages:			0.11

Inputs generated by pe5.pl - Novemeber 2006

Data used for this run:

Output File: TX R_02_E

Metfile: w13958.dvf

PRZM scenario: TurfBSS.txt

EXAMS environment file: pond298.exv

Chemical Name: Coumaphos

Description	Variable Name	Value	Units	Comments
Molecular weight	mwt	362.5	g/mol	

Henry's Law Const.	henry	2.62E-09	atm-m^3/mol	
Vapor Pressure	vapr	1.00E-07	torr	
Solubility	sol	20	mg/L	
Kd	Kd		mg/L	
Koc	Koc	5904	mg/L	
Photolysis half-life	kdp	1.38	days	Half-life
Aerobic Aquatic Metabolism	kbacw	0	days	Halfife
Anaerobic Aquatic Metabolism	kbacs	0	days	Halfife
Aerobic Soil Metabolism	asm	0	days	Halfife
Hydrolysis:	pH 7	0	days	Half-life
Method:	CAM	1	integer	See PRZM manual
Incorporation Depth:	DEPI		cm	
Application Rate:	TAPP	0.009	kg/ha	
Application Efficiency:	APPEFF	1	fraction	
Spray Drift	DRFT	0	fraction of application rate applied to pond	
Application Date	Date	15-01	dd/mm or dd/mmm or dd-mm or dd-mmm	
Interval 1	interval	10	days	Set to 0 or delete line for single app.
app. rate 1	apprate		kg/ha	
Interval 2	interval	10	days	Set to 0 or delete line for single app.
app. rate 2	apprate		kg/ha	
Interval 3	interval	90	days	Set to 0 or delete line for single app.
app. rate 3	apprate		kg/ha	
Interval 4	interval	10	days	Set to 0 or delete line for single app.
app. rate 4	apprate		kg/ha	
Interval 5	interval	10	days	Set to 0 or delete line for single app.
app. rate 5	apprate		kg/ha	

Interval 6	interval		90	days	Set to 0 or delete line for single app.
app. rate 6	apprate			kg/ha	
Interval 7	interval		10	days	Set to 0 or delete line for single app.
app. rate 7	apprate			kg/ha	
Interval 8	interval		10	days	Set to 0 or delete line for single app.
app. rate 8	apprate			kg/ha	
Interval 9	interval		90	days	Set to 0 or delete line for single app.
app. rate 9	apprate			kg/ha	
Interval 10	interval		10	days	Set to 0 or delete line for single app.
app. rate 10	apprate			kg/ha	
Interval 11	interval		10	days	Set to 0 or delete line for single app.
app. rate 11	apprate			kg/ha	
Record 17:	FILTRA				
	IPSCND		1		
	UPTKF				
Record 18:	PLVKRT				
	PLDKRT				
	FEXTRC		0.5		
Flag for Index Res. Run	IR	EPA Pond			
Flag for runoff calc.	RUNOFF	none		none, monthly or total(average of entire run)	

Appendix B: KABAM Analyses

Table B-1. Input Parameters for KABAM Modeling

<table>
<tr><th rowspan="2">Sources of a.i. from Application Scenario</th><th rowspan="2">PRZM/ EXAMS Scenario</th><th rowspan="2">Wash-Off Fraction</th><th colspan="3">Input Parameters</th></tr>
<tr><th>Water Column 21-day EEC$_{(parent)}$ (µg/L) (Coumaphos)</th><th>Pore Water 21-day EEC$_{(parent)}$ (µg/L) (Coumaphos)</th><th>Other Parameters</th></tr>
<tr><td colspan="5">Texas: Spray Application (42% flowable concentrate)</td><td rowspan="7">Log Kow = 4.3
Koc = 5904 L/kg OC

$Km_{(fish)}$ = 0.936*

Avian LD_{50} = 2.4 mg/kg-bw
Avian LC_{50} = 82.1 mg/kg-diet
(bobwhite quail; MRID 00112843)

Avian NOAEC: No data

Mammalian LD_{50} = 17 mg/kg-bw
(rat; MRID 00110597)

Mammalian NOAEC = 25 mg/kg-diet
(rat; MRID 43061701)</td></tr>
<tr><td>Runoff from non-regulated small CAFO</td><td>BSSTurf</td><td>0.02</td><td>0.25</td><td>0.17</td></tr>
<tr><td>Wash-off from the skin of 100 cows that enter a body of water</td><td>NA</td><td>0.02</td><td>0.8</td><td>0.5</td></tr>
<tr><td colspan="5">Rest of U.S.: Back Rubber Application (11.6% emulsifiable concentration)</td></tr>
<tr><td>Runoff from non-regulated small CAFO</td><td>PA Turf</td><td>0.116</td><td>0.29</td><td>0.19</td></tr>
<tr><td>Wash-off from the skin of 100 cows that enter a body of water</td><td>NA</td><td>0.116</td><td>0.4</td><td>0.3</td></tr>
</table>

* Raw data from the BCF study was used to calculate a fish Km of 0.936/day

Appendix C: ECOTOX Literature Search – Papers That Were Accepted

April 2012 refresh

1. Barnard, D. R.; Jones, B. G.; Rogers, G. D., and Mount, G. A. Acaricide Susceptibility in the Lone Star Tick: Assay Techniques and Baseline Data. J. Econ. Entomol.; 1981; 74, (4): 466-469.
   Notes: EcoReference No.: 113406
   Chemical of Concern: AMZ,CBL,CMPH,CPY,DZ,HCCH,MLN,MXC,PMR,PPCP,PSM,TVP,TXP

2. Bevk, D.; Kralj, J., and Cokl, A. Coumaphos Affects Food Transfer Between Workers of Honeybee Apis mellifera. Apidologie; 2012; 43, (4): 465-470.
   Notes: EcoReference No.: 157842
   Chemical of Concern: CMPH

3. Currie, R. W. and Gatien, P. Timing Acaricide Treatments to Prevent Varroa destructor (Acari: Varroidae) from Causing Economic Damage to Honey Bee Colonies. Can. Entomol.; 2006; 138, (2): 238-252.
   Notes: EcoReference No.: 157767
   Chemical of Concern: CMPH,FMA,TAUF

4. Damiani, N.; Gende, L. B.; Bailac, P.; Marcangeli, J. A., and Eguaras, M. J. Acaricidal and Insecticidal Activity of Essential Oils on Varroa destructor (Acari: Varroidae) and Apis mellifera (Hymenoptera: Apidae). Parasitol. Res.; 2009; 106, (1): 145-152.
   Notes: EcoReference No.: 155629
   Chemical of Concern: CMPH,LAVDN,THYME,VFOIL

5. DeVaney, J. A. and Ivie, G. W. Systemic Activity of Coumaphos, Famphur, Crufomate, Ronnel, and Phosmet Given Orally to Hens for Control of the Northern Fowl Mite, Ornithonyssus sylviarum (Canestrini and Fanzago). Poult. Sci.; 1980; 59, 1208-1210.
   Notes: EcoReference No.: 48673
   Chemical of Concern: CMPH,PSM

6. Drummond, R. O. Susceptibility of the Cayenne Tick to Acaricides. J. Econ. Entomol.; 1981; 74, (4): 470-472.
   Notes: EcoReference No.: 113468
   Chemical of Concern: AMZ,AsTO,CBL,CMPH,CPY,DDT,DZ,ETN,FNTH,HCCH,MLN,PPCP,PPHD,PSM,TCF,TVP,TXP

7. Drummond, R. O.; Gladney, W. J.; Whetstone, T. M., and Ernst, S. E. Laboratory Testing of Insecticides for Control of the Winter Tick. J. Econ. Entomol.; 1971; 64, (3): 686-688.
   Notes: EcoReference No.: 113239
   Chemical of Concern: As,CBL,CMPH,CPY,DZ,ETN,FNTH,HCCH,MLN,PPCP,PPHD,PPX,PSM,RTN,TCF,TVP,TXP

8. ---. Testing of Insecticides Against the Tropical Horse Tick in the Laboratory. J. Econ. Entomol.; 1971; 64, (5): 1164-1166.
   Notes: EcoReference No.: 113240
   Chemical of Concern: As,CBL,CMPH,CPY,DZ,ETN,FNTH,HCCH,MLN,PPCP,PPHD,PPX,PSM,TCF,TVP,TXP

9. Elzen, P. J.; Westervelt, D., and Lucas, R. Formic Acid Treatment for Control of Varroa destructor (Mesostigmata: Varroidae) and Safety to Apis mellifera (Hymenoptera: Apidae) Under Southern United States Conditions. J. Econ. Entomol.; 2004; 97, (5): 1509-1512.
   Notes: EcoReference No.: 100404
   Chemical of Concern: CMPH,FMA

10. Gregorc, A. and Ellis, J. D. Cell Death Localization In Situ in Laboratory Reared Honey Bee (Apis mellifera L.) Larvae Treated with Pesticides. Pestic. Biochem. Physiol.; 2011; 99, (2): 200-207.
Notes: EcoReference No.: 156418
Chemical of Concern: AMZ,CMPH,CPY,CTN,FVL,GYP,IMC,MYC,SZ

11. Gregorc, A.; Evans, J. D.; Scharf, M., and Ellis, J. D. Gene Expression in Honey Bee (Apis mellifera) Larvae Exposed to Pesticides and Varroa mites (Varroa destructor). J. Insect Physiol.; 2012; 58, (8): 1042-1049.
Notes: EcoReference No.: 157769
Chemical of Concern: AMZ,CMPH,CPY,CTN,FVL,GYP,IMC,MYC,SZ

12. Johnson, R. M.; Pollock, H. S., and Berenbaum, M. R. Synergistic Interactions Between In-Hive Miticides in Apis mellifera. J. Econ. Entomol.; 2009; 102, (2): 474-479.
Notes: EcoReference No.: 119503
Chemical of Concern: CMPH,PPB,TAUF,TBF

13. Karabacak, M.; Kanbur, M.; Eraslan, G., and Sarica, Z. S. The Antioxidant Effect of Wheat Germ Oil on Subchronic Coumaphos Exposure in Mice. Ecotoxicol. Environ. Saf.; 2011; 74, (7): 2119-2125.
Notes: EcoReference No.: 157622
Chemical of Concern: CMPH

14. Kitchin, K. T. and Brown, J. L. Biochemical Studies of Promoters of Carcinogenesis in Rat Liver. Teratog. Carcinog. Mutagen.; 1989; 9, (5): 273-285.
Notes: EcoReference No.: 103823
Chemical of Concern: CMPH,EDTA,MRX,TXP

15. Koch, H. G. and Burkwhat, H. E. Susceptibility of the American Dog Tick (Acari: Ixodidae) to Residues of Acaricides: Laboratory Assays. J. Econ. Entomol.; 1983; 76, (2): 337-339.
Notes: EcoReference No.: 113231
Chemical of Concern: AMZ,ATN,BDC,CBL,CHD,CMPH,CPY,DZ,FNTH,HCCH, MLN,MXC, Naled,PMR,PPCP,PPX, PSM,RSM,RTN,TCF,TVP,TXP

16. Miller, J. E. Epidemiology and Economics of Strongylate Nematode Parasites of the Bovine in Central California. Ph.D. Thesis, University of California, Davis, CA; 1983: 217 p. (UMI# 407917).
Notes: EcoReference No.: 157924
Chemical of Concern: CMPH,TBA

17. Miller, R. W.; Gordon, C. H.; Morgan, N. O.; Bowman, M. C., and Beroza, M. Coumaphos as a Feed Additive for the Control of House Fly Larvae in Cow Manure. J. Econ. Entomol.; 1970; 63, (3): 853-855.
Notes: EcoReference No.: 103849
Chemical of Concern: CMPH

18. Robbins, W. E.; Hopkins, T. L., and Darrow, D. I. Synergistic Action of Piperonyl Butoxide with Bayer 21/199 and Its Corresponding Phosphate in Mice. J. Econ. Entomol.; 1959; 52, 660-663.
Notes: EcoReference No.: 157619
Chemical of Concern: CMPH,CMPO,PPB

19. Smodis Skerl, M. I. and Gregorc, A. Heat Shock Proteins and Cell Death In Situ Localisation in Hypopharyngeal Glands of Honeybee (Apis mellifera carnica) Workers After Imidacloprid or Coumaphos Treatment. Apidologie; 2010; 41, (1): 73-86.
Notes: EcoReference No.: 157832
Chemical of Concern: CMPH,IMC

20. Su, M. Q.; Kinoshita, F. K.; Frawley, J. P., and DuBois, K. P. Comparative Inhibition of Aliesterases and

Cholinesterase in Rats Fed Eighteen Organophosphorus Insecticides. Toxicol. Appl. Pharmacol.; 1971; 20, (2): 241-249.
Notes: EcoReference No.: 38991
Chemical of Concern: AZ,CMPH,DEM,DMT,DS,EPRN,ETN,FNTH,MLN,MP,MVP,PRN

21. Takagi, H. and Block, E. Effects of Feeding Coumaphos to Dairy Cows at Various Stages of Lactation on Subclinical Parasite Infection and Milk Production. Can. J. Anim. Sci.; 1986; 66, (1): 141-150.
Notes: EcoReference No.: 101801
Chemical of Concern: CMPH

22. White, R. D. Mutagenic and Toxicologic Implications of Pyrrolizidine (Senecio) Alkaloids. Ph.D. Thesis, Oregon State University, OR; 1983: 105 p. (UMI# 8227585) (Publ. in part as 118136, 157929).
Notes: EcoReference No.: 157925
Chemical of Concern: CBL,CMPH,Cu,MLN,PPCP

April 2008 search

1. Astroff, A. B.; Freshwater, K. J., and Eigenberg, D. A. Comparative Organophosphate-Induced Effects Observed in Adult and Neonatal Sprague-Dawley Rats During the Conduct of Multigeneration Toxicity Studies. Reprod. Toxicol.; 1998; 12, (6): 619-645.
Notes: EcoReference No.: 88895
Chemical of Concern: TCF,TBF,OXD,FMP,CMPH

2. Brody, G. and Elward, T. E. Comparative Activity of 29 Known Anthelmintics Under Standarized Drug-Diet and Gavage Medication Regimens Against Four Helminth Species in Mice. J. Parasitol.; 1971; 57, (5): 1068-1077.
Notes: EcoReference No.: 101241
Chemical of Concern: DDVP,CMPH,NSM,TBA,TCF

3. Carlson, C. A. Effects of Three Organophosphorus Insecticides on Immature Hexagenia and Hydropsyche of the Upper Mississippi River. Trans. Am. Fish. Soc.; 1966; 95, (1): 1-5.
Notes: EcoReference No.: 2158
Chemical of Concern: CMPH,MLN

4. Collins, A. M.; Pettis, J. S.; Wilbanks, R., and Feldlaufer, M. Performance of Honey Bee (Apis mellifera) Queens Reared in Beeswax Cells Impregnated with Coumaphos. J. Apic. Res.; 2004; 43, (3): 128-134.
Notes: EcoReference No.: 100380
Chemical of Concern: CMPH

5. Cox, D. D.; Mullee, M. T., and Allen, A. D. Anthelmintic Activity of Two Organic Phosphorus Compounds, Coumaphos and Naphthalophos, Against Gastrointestinal Nematodes of Cattle. Am. J. Vet. Res.; 1967; 28, (122): 79-88.
Notes: EcoReference No.: 100916
Chemical of Concern: CMPH

6. ---. Cattle Grub Control with Feed Additives (Coumaphos and Fenthion) and Pour-ons (Fenthion and Trichlorfon). J. Econ. Entomol.; 1967; 60, (2): 522-527.
Notes: EcoReference No.: 101195
Chemical of Concern: TCF,FNTH,CMPH

7. ---. Effect of Coumaphos and Fenthion Feed Additives on Gastrointestinal Nematode Egg Counts in Feedlot Cattle. Am. J. Vet. Res.; 1969; 30, (11): 1933-1943.
Notes: EcoReference No.: 100914
Chemical of Concern: CMPH,FNTH

8. Davis, H. C. and Hidu, H. Effects of Pesticides on Embryonic Development of Clams and Oysters and on Survival and Growth of the Larvae. Fish. Bull.; 1969; 67, (2): 393-404.
Notes: EcoReference No.: 2400
Chemical of Concern: EDT,24DXY,AZ,CBL,CMPH,DS,DU,HCCH,MLN,PCP,PRN, DDT,NaPCP, DZ, DBAC,DCB,TCC

9. Dawe, D. L.; Brown, J.; Davis, R. B., and Kellogg, F. E. Effectiveness of Maretin and Meldane as Treatments for Capillariasis in Bobwhites. Avian Dis.; 1969; 13, (3): 662-667.
Notes: EcoReference No.: 101108
Chemical of Concern: CMPH

10. Elzen, P. J. Suitability of Formic Acid to Control Varroa destructor and Safety to Apis mellifera in the Southwestern U.S. Southwest. Entomol.; 2003; 28, (4): 261-266.
Notes: EcoReference No.: 101098
Chemical of Concern: FMA,CMPH,FVL

11. Faulkner, L. C.; Carroll, E. J., and Benjamin, M. Effect of Coumaphos on Bulls. J. Am. Vet. Med. Assoc.; 1964; 145, (5): 456-459.
Notes: EcoReference No.: 101192
Chemical of Concern: CMPH

12. Folz, S. D.; Pax, R. A.; Thomas, E. M.; Bennett, J. L.; Lee, B. L., and Conder, G. A. Detecting In Vitro Anthelmintic Effects with a Micromotility Meter. Vet. Parasitol.; 1987; 24, (3/4): 241-250.
Notes: EcoReference No.: 101182
Chemical of Concern: CMPH

13. ---. Development and Validation of an In Vitro Trichostrongylus colubriformis Motility Assay. Int. J. Parasitol.; 1987; 17, (8): 1441-1444.
Notes: EcoReference No.: 101170
Chemical of Concern: CMPH

14. Glenn, J. S.; Baker, N. F.; Franti, C. E., and Ver Steeg, J. D. Anthelmintic Treatment of Nonpastured Dairy Cows in California. J. Dairy Sci.; 1982; 65, (10): 2006-2010.
Notes: EcoReference No.: 101239
Chemical of Concern: CMPH

15. Haarmann, T.; Spivak, M.; Weaver, D.; Weaver, B., and Glenn, T. Effects of Fluvalinate and Coumaphos on Queen Honey Bees (Hymenoptera: Apidae) in Two Commercial Queen Rearing Operations. J. Econ. Entomol.; 2002; 95, (1): 28-35.
Notes: EcoReference No.: 66848
Chemical of Concern: FVL,CMPH

16. Heath, R. G. ; Spann, J. W.; Hill, E. F., and Kreitzer, J. F. Comparative Dietary Toxicities of Pesticides to Birds. pecial Scientific Report Wildlife 152, Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, Washington, DC; 1972: 57 p.
Notes: EcoReference No.: 35214
Chemical of Concern: TMP,AND,AMTL,ATZ,PPX,Captan,CHL,CHD,TCF,24DXY,DDT,24DB, DDVP,DEM,DEZ,DBN,DCF,DLD,DS,CU,CPY,DMT,SZ,FNF,ES,EN,TXP,FNT,FNTH,AZ,HPT,PSM,HCCH,MLN,MCPB,MTAS,MOM,MXC,MP,MRX,Nabam,Naled,OXC,PRN,PCP,PRT,PPHD, PCL,TFM,THM,PPG,CMPH,OXD,DZ

17. Hill, E. F. and Camardese, M. B. Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix. Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix; 1986: 147 p.
Notes: EcoReference No.: 50181

Chemical of Concern: 24D,24DXY,ACP,ADC,AMSV,AMTL,AND,ARM,ATN,ATZ,AZ,BMC,BMN,BMY,Captan,CBF,CBL,CdCl,CHD,CMPH,CPY,CPYM,CrS,DBN,DCF,DCTP,DDT,DDVP,DEM,DFPM,DINO,DLD,DMB,DMT,DQTBr,DS,DU,DZ,EN,EP,ES,ETN,FMP,FNF,FNT,FNTH,FTTCl,GYP,HCCH,HgCl2,HPT,IFP,K2Cr207,LNR,Maneb,MCB,MCPB,MDT,MLN,MLT,MOM,MP,MRX,MSMA,MTAS,MTM,MVP,MXC,Naled,Ni,OXD,Pb,PbN,PCB,PCL,PCP,PHSL,PMR,PPB,PPHD,PPN,PPX,PQT,PRN,PRT,PSM,PYN,RSM,RTN,SPS,SZ,TBO,TCF,TEPP,TFN,THM,TMP,TVMP, TVP,V,Zineb,Ziram,ZnP

18. Hill, E. F.; Heath, R. G.; Spann, J. W., and Williams, J. D. Lethal Dietary Toxicities of Environmental Pollutants to Birds. U.S.Fish and Wildl.Serv.No.191, Special Scientific Report-Wildlife; 1975: 61 p.
Notes: EcoReference No.: 35243
Chemical of Concern: 24DXY,TMP,ADC,AMTL,AND,ATZ,Captan,CBF,CBL,Cd,Cr,DDT,DLD,DMT,DS,DU,DZ,ES,ETN,FNT,HCCH,Hg,HPT,MCPB,MLN,MP,MRX,MTAS,MXC,Naled,Pb,PCB,PCL,PCP,PQT,PRN,PRT,PYN,RSM,RTN,SZ,TFM,THM,TVP,TXP,Zn,ZnP,As,AZ,OXD,PSM,LNR,PPG,CYP,PEM,MOM,DDVP,PHTH,DBN,CMPH,TVPM

19. Hudson, R. H.; Tucker, R. K., and Haegele, M. A. Handbook of Toxicity of Pesticides to Wildlife. Resource Publication 153, Fish and Wildlife Service, U.S. Department of the Interior; 1984: 90 p.
Notes: EcoReference No.: 50386
Chemical of Concern: ACP,ACL,ACR,ADC,AND,ATN,AMTL,ANZ,ATZ,4AP,AZ,PPX,BTY,Captan,CBL,CBF,CHD,CQTC,CPY,CMPH,CZE,24D,DDT,DDVP,DEF,DEM,DZ,DBN,DLN,DCF,DCTP,DLD,DMT,DQTBr,DS,DU,ES,EDT,EN,EP,ETN,FNT,FNTH,FMV,Folpet,FNF,HPT,PSM,HCCH,MLN,MDT,MCB,MOM,MTPN,MXC,MP,MVP,MRX,NABAM,Naled,FMP,PQT,PRN,PCP,PRT,PCL,PSM,RTN,STAR,STCH,TCDD,TMP,TZL,TVP,TZL,THM,TXP,TCF,TFN,ZnP,Zineb,PCB

20. Katz, M. Acute Toxicity of Some Organic Insecticides to Three Species of Salmonids and to the Threespine Stickleback. Trans. Am. Fish. Soc.; 1961; 90, (3): 364-368.
Notes: EcoReference No.: 522
Chemical of Concern: CMPH,TXP,AND,DLD,DDT,HCCH,MXC,HPT,CHD,EN,AZ,MLN,CBL

21. Knapp, F. W. The Effect of Free-Choice Coumaphos Salt Mixtures on Cattle and Cattle Parasites. J. Econ. Entomol.; 1965; 58, (2): 197-199.
Notes: EcoReference No.: 101238
Chemical of Concern: CMPH

22. Landrum, P. F.; Fisher, S. W.; Hwang, H., and Hickey, J. Hazard Evaluation of Ten Organophosphorus Insecticides Against the Midge, Chironomus riparius via QSAR. MOR. P.F.Landrum, Great Lakes Environmental Research Laboratory, NOAA, Ann Arbor, MI, 48105: SAR QSAR Environ.Res.; 1999; 10, (5): 423-450.
Notes: EcoReference No.: 67687
Chemical of Concern: FNF,TBO,CMPH,DCTP,FNTH,AZ,CPY,DZ,DS

23. Leland, S. E. Jr.; Ridley, R. K.; Dick, J. W.; Slonka, G. F., and Zimmerman, G. L. Anthelmintic Activity of Trichlorfon, Coumaphos, and Naphthalophos Against the In Vitro Grown Parasitic Stages of Cooperia punctata. J. Parasitol.; 1971; 57, (6): 1190-1197.
Notes: EcoReference No.: 101240
Chemical of Concern: TCF,CMPH

24. Maronpot, R. R.; Shimkin, M. B.; Witschi, H. P.; Smith, L. H., and Cline, J. M. Strain A Mouse Pulmonary Tumor Test Results for Chemicals Previously Tested in the National Cancer Institute Carcinogenicity Tests. MOR,PHYINJECT; 1986; 76, (6): 1101-1112.
Notes: EcoReference No.: 91262
Chemical of Concern: Captan,DZ,PRN,AND,EDB,TXP,CMPH,DNT

25. Miller, J. E.; Baker, N. F., and Farver, T. B. Anthelmintic Treatment of Pastured Dairy Cattle in California.

Am. J. Vet. Res.; 1986; 47, (9): 2036-2040.
Notes: EcoReference No.: 101152
Chemical of Concern: TBA,CMPH

26. Miller, R. W. and Long, P. P. Effect of Feeding Coumaphos on Feed Intake and Rate of Gain of Steers. J. Dairy Sci.; 1974; 57, (6): 723-725.
Notes: EcoReference No.: 37967
Chemical of Concern: CMPH

27. National Cancer Institute. Bioassay of Coumaphos for Possible Carcinogenicity. NCI Tech.Rep.Ser.#96, Natl.Cancer Inst., Bethesda, MD; 1979: 100 p.
Notes: EcoReference No.: 100567
Chemical of Concern: CMPH

28. Nelson, D. L.; Mozier, J. O.; White, R. G., and Allen, A. D. The Pharmacological Effect of Baymix (Coumaphos) on Poultry. Poult. Sci.; 1968; 47, (3): 960-962.
Notes: EcoReference No.: 101256
Chemical of Concern: CMPH

29. Pardio, V. T.; De Ibarra, N. J.; Waliszewski, K. N., and Lopez, K. M. Effect of Coumaphos on Cholinesterase Activity, Hematology, and Biochemical Blood Parameters of Bovines in Tropical Regions of Mexico. J. Environ. Sci. Health Part B: Pestic. Food Contam. Agric. Wastes; 2007; 42, (4): 359-366.
Notes: EcoReference No.: 100839
Chemical of Concern: CMPH

30. Pardio, V. T.; Ibarra, N.; Rodriguez, M. A., and Waliszewski, K. N. Use of Cholinesterase Activity in Monitoring Organophosphate Pesticide Exposure of Cattle Produced in Tropical Areas. J. Agric. Food Chem.; 2001; 49, (12): 6057-6062.
Notes: EcoReference No.: 100382
Chemical of Concern: FNTH,CMPH

31. Pettis, J. S.; Collins, A. M.; Wilbanks, R., and Feldlaufer, M. F. Effects of Coumaphos on Queen Rearing in the Honey Bee, Apis mellifera. Apidologie; 2004; 35, (6): 605-610.
Notes: EcoReference No.: 100910
Chemical of Concern: CMPH

32. Rettich, F. Laboratory and Field Investigations in Czechoslovakia with Fenitrothion, Pirimiphos-Methyl, Temephos and Other Organophosphorous Larvicides. Mosq. News; 1979; 39, (2): 320-328 (Author Communication Used).
Notes: EcoReference No.: 5162
Chemical of Concern: CPY,DZ,MLN,CMPH,DMT,Naled,DDT,FNT,PIRM,TMP,TCF,DDVP,TVP

33. Sanchez-Fortun, S.; Sanz-Barrera, F., and Barahona-Gomariz, M. V. Acute Toxicities of Selected Insecticides to the Aquatic Arthropod Artemia salina. Bull. Environ. Contam. Toxicol.; 1995; 54, (1): 76-82.
Notes: EcoReference No.: 14997
Chemical of Concern: CMPH,AZ,DDVP,DDT,DLD,HCCH

34. Sanders, H. O. Toxicity of Some Insecticides to Four Species of Malacostracan Crustaceans. Tech.Pap.No.66, Bur.Sports Fish.Wildl., Fish Wildl.Serv., U.S.D.I., Washington, D.C.; 1972: 19 p. (Publ in Part As 6797).
Notes: EcoReference No.: 887
Chemical of Concern: ATN,ES,AZ,MLN,MXC,Naled,DS,PRT,CBL,DLD,EN,CHD,AND,DDT,TXP,HPT,CPY,CMPH,OXD,DZ

35. Silvestri, R.; Himes, J. A., and Edds, G. T. Repeated Oral Administration of Coumaphos in Sheep: Effects on Erythrocyte Acetylcholinesterase and Other Constituents. Am. J. Vet. Res.; 1975; 36, (3): 283-287.
Notes: EcoReference No.: 38777
Chemical of Concern: CMPH

36. Van Buren, N. W. M.; Marien, A. G. H.; Oudejans, R. C. H. M., and Velthuis, H. H. W. Perizin, an Acaricide to Combat the Mite Varroa jacobsoni: Its Distribution in and Influence on the Honeybee Apis mellifera. Physiol. Entomol.; 1992; 17, (3): 288-296.
Notes: EcoReference No.: 101175
Chemical of Concern: CMPH

37. Weick, J. and Thorn, R. S. Effects of Acute Sublethal Exposure to Coumaphos or Diazinon on Acquisition and Discrimination of Odor Stimuli in the Honey Bee (Hymenoptera: Apidae). MOR,BCM,BEH. J.Weick, Dep. of Biol., Denison Univ., Granville, OH 43203: J. Econ. Entomol.; 2002; 95, (2): 227-236.
Notes: EcoReference No.: 87972
Chemical of Concern: CMPH,DZ

38. Willford, W. A. Toxicity of 22 Therapeutic Compounds to Six Fishes. Invest.Fish Control No.18, Resourc.Publ.No.35, Fish Wildl.Serv., Bur.Sport Fish.Wildl., USDI, Washington, DC; 1966: 10 p.
Notes: EcoReference No.: 2524
Chemical of Concern: CMPH,Ni,DBAC

39. Wilton, D. P.; Fetzer, L. E. Jr., and Fay, R. W. Insecticide Baits for Anopheline Larvae. Mosq. News; 1973; 33, (2): 198-203.
Notes: EcoReference No.: 13956
Chemical of Concern: FNTH,FNT,CMPH,CBL,MXC,MCB,CPY,RSM,CPYM,TMP

Appendix D: ECOTOX Literature Search – Papers That Were Not Acceptable

April 2012 refresh

1. Alabaster, J. S. Survival of Fish in 164 Herbicides, Insecticides, Fungicides, Wetting Agents and Miscellaneous Substances. MORAQUA; 1969; 11, (2): 29-35 (Author Communication Used).
   Notes: EcoReference No.: 542
   Chemical of Concern:
   24D,24DXY,24DXYBEE,ACHY,ACL,AMTL,ATZ,BHAP,BOR,BORON,BRA,BSN881,CAP,CMPH,CPA,CuOX,DBN,DDT,DINO,DIOSSNa,DQTBr,DZ,DZM,FUR,MCPP1,MEM,MLH,MTAS,NaClO,NaDPA,NaDSS,NaPCP,PCLK,PL,PQT,PYZ,SZ,TBTO,TFN,TRL

2. Aziz, S. A. Toxicity of Certain Insecticide Standards Against the Southern Armyworm. MORTOP; 1973; 66, (1): 68-70.
   Notes: EcoReference No.: 112632
   Chemical of Concern:
   ADC,AND,AZ,CBF,CBL,CMPH,CPY,DDT,DDVP,DEM,DLD,DMT,DS,DZ,EN,EPRN,HCCH,HPT,MP,MVP,PPCP,PRN,PRT,PSM,TCF,TMP,TXP

3. Bacandritsos, N.; Papanastasiou, I.; Saitanis, C.; Nanetti, A., and Roinioti, E. Efficacy of Repeated Trickle Applications of Oxalic Acid in Syrup for Varroosis Control in Apis mellifera: Influence of Meteorological Conditions and Presence of Brood. MOR,POPENV,MIXTURE; 2007; 148, (2): 174-178.
   Notes: EcoReference No.: 151746
   Chemical of Concern: CMPH,OXAC

4. Beatty, J. F.; Arnold, B. L.; McGee, W. H.; Custer, E. W., and Daniels, J. W. The Effect of "Baymix" on Milk Production and Milk Quality. PHY,REP. Mississippi Agricultural and Forestry Experiment Station//: ORAL; 1974; 37, (9): 8.
   Notes: EcoReference No.: 157765
   Chemical of Concern: CMPH

5. Beugnet, F. and Chardonnet, L. Tick Resistance to Pyrethroids in New Caledonia. MORENV; 1995; 56, (4): 325-338.
   Notes: EcoReference No.: 115241
   Chemical of Concern: CMPH,CPY,DM,DZ,ETN,FNTH,FNV,PTP

6. Bonzini, S.; Tremolada, P.; Bernardinelli, I.; Colombo, M., and Vighi, M. Predicting Pesticide Fate in the Hive (Part 1): Experimentally Determined Tau-Fluvalinate Residues in Bees, Honey and Wax. ACC. [Tremolada, P] Univ Milan, Dept Biol, I-20133 Milan, Italy//: ENV; 2011; 42, (3): 378-390.
   Notes: EcoReference No.: 157830
   Chemical of Concern: AMZ,CMPH,MLN,PMR,TAUF

7. Burley, L. M.; Fell, R. D., and Saacke, R. G. Survival of Honey Bee (Hymenoptera: Apidae) Spermatozoa Incubated at Room Temperature from Drones Exposed to Miticides. POP,REP. lmburley@vt.edu//: ENV; 2008; 101, (4): 1081-1087.
   Notes: EcoReference No.: 107876
   Chemical of Concern: CMPH,TAUF,TML

8. Butler, P. A. Commercial Fishery Investigations. ACC,BEH,GRO,MOR,PHY,POP,SYSAQUA; 1964: 28 p. (Author Communication Used).
   Notes: EcoReference No.: 646
   Chemical of Concern:

24DXY,24DXYBEE,24DXYEE,AND,ANZ,AZ,CBL,CMPH,DCPA,DCTP,DDT,DDVP,DEM,DLD,DMDP,DMT,DQT,DQTBr,DS,DU,EN,EPRN,EPTC,ES,ETN,FNT,FNTH,HCCH,HPT,MCB,MCPAD,MLN,MP,MRX,MVP,MXC,NTP,Naled,PAQT,PEB,PPCP,PPHD,PPX,PQT,PRN,PRT,PSM,TBF,TCF,TMP,TVP,TXP

9. Byford, R. L. ; Sparks, T. C.; Green, B.; Knox, J., and Wyatt, W. Organophosphorus Insecticides for the Control of Pyrethroid-Resistant Horn Flies (Diptera: Muscidae). MOR,POPENV,MIXTURE,TOP; 1988; 81, (6): 1562-1566.
Notes: EcoReference No.: 114522
Chemical of Concern: CMPH,CPY,DMT,DZ,ETN,FNV,MLN,PIRM,PMR,TCF,TVP

10. Castella, J. and Estrada, A. Susceptibility of the Brown Dog Tick to Eight Acaricides, 1991. MORTOP; 1994; 19, 371-(4L).
Notes: EcoReference No.: 106250
Chemical of Concern: AMZ,CMPH,CYP,DM,DZ,PMR

11. Dorough, H. W.; Brady, U. E. Jr.; Timmerman, J. A., and Arthur, B. W. Residues in Tissues and Eggs of Poultry Receiving Co-Ral (Bayer 21/199) in the Feed. ACC,REPORAL; 1961; 54, 97-100.
Notes: EcoReference No.: 103834
Chemical of Concern: CMPH

12. Drummond, R. O. Susceptibility of the Gulf Coast Tick (Acari: Ixodidae) to Acaricides. REPTOP; 1988; 81, (4): 1140-1142.
Notes: EcoReference No.: 114521
Chemical of Concern: AMZ,AsTO,CBL,CMPH,CPY,DZ,HCCH,MLN,PMR,PPCP,PSM,TVP,TXP

13. Drummond, R. O.; Ernst, S. E.; Trevino, J. L., and Graham, O. H. Insecticides for Control of the Cattle Tick and the Southern Cattle Tick on Cattle. POPTOP; 1968; 61, (2): 467-470.
Notes: EcoReference No.: 113241
Chemical of Concern: CBL,CMPH,CPY,DZ,ETN,FNTH,PPX,PSM

14. Drummond, R. O.; Whetstone, T. M.; Ernst, S. E., and Gladney, W. J. Control of Three-Host Ticks. Laboratory Tests of Systemic Insecticides in Feed of Cattle. MOR,PHY,POP,REPENV,ORAL; 1972; 65, (6): 1641-1644.
Notes: EcoReference No.: 114791
Chemical of Concern: CMPH,FNTH,PSM

15. Drummond, R. O.; Whetstone, T. M.; Shelley, B. K., and Barrett, C. C. Common Cattle Grub: Control with Animal Systemic Insecticides. MOR,POPENV; 1977; 70, (2): 176-178.
Notes: EcoReference No.: 113371
Chemical of Concern: CMPH,FNTH,MTPN,PSM,TCF

16. Gladney, W. J.; Ernst, S. E.; Dawkins, C. C.; Drummond, R. O., and Graham, O. H. Feeding Systemic Insecticides to Cattle for Control of the Tropical Horse Tick. GRO,MOR,POP,REPENV; 1972; 9, (5): 439-442.
Notes: EcoReference No.: 115592
Chemical of Concern: CMPH,FNTH,PSM

17. Gregorc, A. and Planinc, I. The Control of Varroa destructor Using Oxalic Acid. POPENV,MIXTURE; 2002; 163, (3): 306-310.
Notes: EcoReference No.: 151669
Chemical of Concern: CMPH,OXAC

18. Gregorc, A. and Poklukar, J. Rotenone and Oxalic Acid as Alternative Acaricidal Treatments for Varroa destructor in Honeybee Colonies. MOR,POPENV,MIXTURE; 2003; 111, (4): 351-360.

Notes: EcoReference No.: 76055
Chemical of Concern: CMPH,OXAC,RTN

19. Hansen, M. F. and Zeakes, S. M. Efficacy of Maretin and Baymix Against Nematodes of Calves. POPENV; 1969; 88, (1): 159-161.
Notes: EcoReference No.: 157729
Chemical of Concern: CMPH

20. Higes, M.; Meana, A.; Suarez, M., and Llorente, J. Negative Long-Term Effects on Bee Colonies Treated with Oxalic Acid Against Varroa jacobsoni Oud. MOR,POP,REP. Dpto. Patologia Animal I (Sanidad Animal//: ENV; 1999; 30, (4): 289-292.
Notes: EcoReference No.: 151761
Chemical of Concern: CMPH,OXAC,TAUF

21. Hughes, P. B. and Devonshire, A. L. The Biochemical Basis of Resistance to Organophosphorus Insecticides in the Sheep Blowfly, Lucilia cuprina. ACC,MOR,PHYTOP; 1982; 18 , 289-297.
Notes: EcoReference No.: 71995
Chemical of Concern: CMPH,DZ,EPRN,PRN

22. Jones, K. H.; Sanderson, D. M., and Noakes, D. N. Acute Toxicity Data for Pesticides (1968). MORORAL,TOP; 1968; 7, (3): 135-143.
Notes: EcoReference No.: 70074
Chemical of Concern: 24DXY,ABT,ACL,ADC,AMTL,AMTR,AND,ASM,ATN,ATZ,AZ,BFL,BMC,BMN,BS,BTY,CBL,CCA,CHD,CMPH,CPP,CPY,CQTC,CTHM,Captan,Cu,CuFRA,DBN,DCB,DCNA,DCPA,DDD,DDT,DDVP,DEM,DINO,DLD,DMB,DMT,DOD,DPP,DQTBr,DS,DU,DZ,DZM,EDT,EN,EP,EPRN,EPTC,ES,ETN,FLAC,FMU,FNF,FNT,FNTH,Folpet,HCCH,HPT,LNR,MCB,MCPA,MCPB,MCPP1,MDT,MLH,MLN,MLT,MRX,MTM,MVP,MXC,Maneb,NPM,Naled,PCH,PCL,PCP,PEB,PHMD,PHSL,PMT,PPCP,PPHD,PPN,PPX,PPZ,PQT,PRN,PRO,PRT,PYN,PYZ,Pb,RTN,SFT,SID,SZ,TCF,TFN,THM,TRB,TRL,TXP,VNT,Zineb

23. Kaplanis, J. N.; Hopkins, D. E., and Treiber, G. H. Dermal and Oral Treatments of Cattle with Phosphorus-32-Labeled Co-Ral. ACCTOP; 1959; 7, (7): 483-486.
Notes: EcoReference No.: 157621
Chemical of Concern: CMPH

24. Kitchin, K. T.; Brown, J. L., and Kulkarni, A. P. Ornithine Decarboxylase Induction and DNA Damage as a Predictive Assay for Potential Carcinogenicity. BCM,CELORAL; 1991; 369, 137-144 (Publ in part as 103823).
Notes: EcoReference No.: 103822
Chemical of Concern: CMPH,DDE

25. ---. Predicting Rodent Carcinogenicity of Halogenated Hydrocarbons by In Vivo Biochemical Parameters. BCM,CEL,MORORAL; 1993; 13, (4): 167-184.
Notes: EcoReference No.: 70486
Chemical of Concern: 13DPE,24D,24DXY,CF,CMPH,CQTC,CTC,DCB,DDE,DDT,DDVP,DPDP,DXN,EDB,EN,MRX,PBDE,PNB,TCDD,TXP

26. Kraus, B. and Berg, S. Effect of a Lactic Acid Treatment During Winter in Temperate Climate upon Varroa jacobsoni Oud. and the Bee (Apis mellifera L.) Colony. BEH,MOR,POP,REPENV,MIXTURE; 1994; 18, (8): 459-468.
Notes: EcoReference No.: 100418
Chemical of Concern: CMPH,LLA

27. Krueger, H. R.; Casida, J. E., and Niedermeier, R. P. Animal Metabolism of Insecticides. Bovine Metabolism of Organphosphorus Insecticides. Metabolism and Residues Associated with Dermal Application of Co-ral to Rats, a Goat, and a Cow. ACC,BCMTOP; 1959; 7, (3): 182-188.
Notes: EcoReference No.: 157620
Chemical of Concern: CMPH

28. Lammler, G. and Gruner, D. Chemotherapeutic Studies on Litomosoides carinii Infection of Mastomys natalensis. 6. The Filaricidal Activity of Organophosphorus Compounds. POPINJECT,ORAL; 1975; 26, (3): 359-369.
Notes: EcoReference No.: 104001
Chemical of Concern: CMPH,CPY,FNTH,PSM,TCF

29. Li, A. Y.; Pruett, J. H.; Davey, R. B., and George, J. E. Toxicological and Biochemical Characterization of Coumaphos Resistance in the San Roman Strain of Boophilus microplus (Acari: Ixodidae). BCM,MORTOP; 2005; 81, (3): 145-153.
Notes: EcoReference No.: 80229
Chemical of Concern: 3CE,CMPH,PPB

30. Mao, W.; Schuler, M. A., and Berenbaum, M. R. CYP9Q-Mediated Detoxification of Acaricides in the Honey Bee (Apis mellifera). CEL. Department of Entomology, University of Illinois, Urbana, IL 61801, USA.//: TOP; 2011; 108, (31): 12657-12662.
Notes: EcoReference No.: 156538
Chemical of Concern: BFT,CMPH,CYP,TAUF

31. Mayer, F. L. Jr. Acute Toxicity Handbook of Chemicals to Estuarine Organisms. GRO,MOR,PHY,POPAQUA; 1987: 274 p.
Notes: EcoReference No.: 3947
Chemical of Concern: 24D,24DC,24DXY,24DXYBEE,ACD,ACL,ACP,ADC,ALSV,AMTR,AND,ANZ,ATM,ATZ,AZ,AgN,AsTO,BMC,BS,CAP,CBF,CBL,CCA,CHD,CMPH,CPY,CST,CTN,CYP,Captan,CdCl,DBN,DCF,DCPA,DCTP,DDE,DDT,DDVP,DEM,DFZ,DLD,DMB,DMT,DQTBr,DS,DSMA,DU,DZ,EDT,EN,EP,EPRN,EPTC,ES,ETN,FBM,FMP,FNF,FNT,FNTH,HCB,HCCH,HCCP,HMN,HPT,HgCl2,K2Cr2O7,MCB,MDT,MLN,MLT,MP,MRX,MTAS,MVP,MXC,Maneb,NTP,NaHCT,NaLS,NaPCP,Naled,PCBZ,PCP,PEB,PHTH,PL,PMR,PMT,PPCP,PPHD,PPX,PQT,PRN,PRO,PRT,PSM,RTN,SFR,SZ,TBC,TBF,TBTO,TCF,TDC,TEG,TFN,TMP,TPTH,TRL,VNT,Zineb,Ziram,ZnS

32. McDougald, L. R.; White, R. G., and Hansen, M. F. Efficacy of Naphthalophos and Coumaphos Against Nematodes of Goats. POPENV; 1968; 29, (5): 1077-1079.
Notes: EcoReference No.: 157692
Chemical of Concern: CMPH

33. Miller, R. J.; Li, A. Y.; Tijerina, M.; Davey, R. B., and George, J. E. Differential Response to Diazinon and Coumaphos in a Strain of Boophilus microplus (Acari: Ixodidae) Collected in Mexico. BCM,MOR. robert.miller@ars.usda.gov//USDA-ARS, Cattle Fever Tick Research Laboratory, 22675 N. Moorefield Road, Edinburg, TX 78541////: ENV,MIXTURE; 2008; 45, (5): 905-911.
Notes: EcoReference No.: 119627
Chemical of Concern: CMPH,DZ,PPB

34. Mutinelli, F.; Baggio, A.; Capolongo, F.; Piro, R.; Prandin, L., and Biasion, L. A Scientific Note on Oxalic Acid by Topical Application for the Control of Varroosis. POPENV; 1997; 28, (6): 461-462.
Notes: EcoReference No.: 151767
Chemical of Concern: CMPH,OXAC

35. Nelson, D. L.; White, R. G.; Mozier, J. O., and Allen, A. D. Toxicity of Larger-than-Recommended Doses of Naphthalophos to Cattle, Sheep, and Goats. MOR,PHY,POPENV,MIXTURE,ORAL; 1970; 31, (1): 199-201.

Notes: EcoReference No.: 157873
Chemical of Concern: CMPH,FNTH,TCF

36. Neuhauser, H. and Krieger, K. Chemical Control of Varroa jacobsoni in Honey Bees from the Animal-Health-Industry Aspect. ACC,MOR,POPENV; 1988; 46, 375-379.
Notes: EcoReference No.: 157770
Chemical of Concern: CMPH

37. O'Neill, D. K. and Hebden, S. P. Investigation of Sheep Dips. Part I - Mixtures of Lime Sulphur and Organic Phosphorus Compounds. ACC,MORTOP; 1966; 42, (6): 207-213.
Notes: EcoReference No.: 104226
Chemical of Concern: CMPH,CaPS,DZ

38. Pettis, J. S.; Collins, A. M.; Wilbanks, R., and Feldlaufer, M. Survival and Function of Queens Reared in Beeswax Containing Coumaphos. CEL,GRO,POP,REPENV; 2006; 146, (4): 341-344.
Notes: EcoReference No.: 157886
Chemical of Concern: CMPH,FVL

39. Pfadt, R. E.; Lloyd, J. E., and Spackman, E. W. Power Dusting with Organophosphorus Insecticides to Control the Sheep Ked. POPENV; 1975; 68, (4): 468-470.
Notes: EcoReference No.: 108644
Chemical of Concern: CMPH,PSM

40. Rammell, C. G. and Bentley, G. R. Decay Rates of Organophosphate Residues in the Fleeces of Sheep Dipped for Flystrike Control. ACCTOP; 1989; 32, (2): 213-218.
Notes: EcoReference No.: 101119
Chemical of Concern: CMPH,DZ,PTP

41. Rammell, C. G.; Bentley, G. R., and Heath, A. C. G. Organophosphate Residues in the Wool of Sheep Dipped for Flystrike Control. ACCTOP; 1988; 31, (2): 151-154.
Notes: EcoReference No.: 101118
Chemical of Concern: CMPH,DZ,PTP

42. Rawlins, S. C. and Mansingh, A. Patterns of Resistance to Various Acaricides in Some Jamaican Populations of Boophilus microplus. MORUNK; 1978; 71, 956-960.
Notes: EcoReference No.: 72313
Chemical of Concern:
CBL,CMPH,CPY,DCTP,DDT,DMT,DZ,FNT,HCCH,Naled,PIRM,PPCP,PPHD,PPX

43. Samuel, J. J.; Mani, K. B. S.; Cyrus, I., and Natarajan, R. Studies on the Use of Synthetic Atropine Substitutes in Organo Phosphorus Pesticide Poisoning. MOR. Dep. Pharmacol.,Madras Vet. Coll.,Madras,India////: INJECT,MIXTURE; 1987; 16, (3): 135-136.
Notes: EcoReference No.: 157693
Chemical of Concern: CMPH

44. Schafer, E. W. Jr.; Brunton, R. B.; Lockyer, N. F., and De Grazio, J. W. Comparative Toxicity of Seventeen Pesticides to the Quelea, House Sparrow, and Red-Winged Blackbird. MORORAL,TOP; 1973; 26, 154-157.
Notes: EcoReference No.: 38663
Chemical of Concern: 4AP,CBF,CMPH,DCTP,DEM,EPRN,FNTH,MCB,PRN

45. Shaw, R. D.; Cook, M., and Carson, R. E. Jr. Developments in the Resistance Status of the Southern Cattle Tick to Organophosphorus and Carbamate Insecticides. MORTOP; 1968; 61, 1590-1594.
Notes: EcoReference No.: 72637
Chemical of Concern:

CBL,CMPH,CPY,DCTP,DZ,EPRN,ETN,HCCH,PPCP,PPHD,PRN,PYN,TXP

46. Sun, Y. P. Speed of Action of Insecticides and Its Correlation with Accumulation in Fat and Excretion in Milk. MORENV,TOP; 1971; 64, (3): 624-630.
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Chemical of Concern:
ADC,AND,CBL,CHD,CMPH,DDT,DDVP,DEM,DMT,DS,DZ,EN,EPRN,ES,ETN,FNTH,HCCH,HPT,MLN,MP,MPO,MVP,MXC,Naled,PCTP,PPCP,PPHD,PRN,PRT,PSM,TCF,TVP,TXP

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Notes: EcoReference No.: 157629
Chemical of Concern: CMPH

48. Swierczewska, E.; Niemiec, J., and Noworyta-Glowacka, J. A Note on the Effect of Immunostimulation of Laying Hens on the Lysozyme Activity in Egg White. BCM. Department of Poultry Breeding,Warsaw Agricultural University,Warsaw,Pol////: INJECT,ORAL; 2003; 21, (1): 63-68.
Notes: EcoReference No.: 157623
Chemical of Concern: CMPH